



هيكل 12ADV (حكومي)



EOT Term 1
2025/2026

المادة: الكيمياء

المدرس: طارق محمد

تنذير

إعلان هام من الأكاديمية

تنوه أكاديميتنا إلى ضرورة الحفاظ على حقوق الملكية الفكرية الخاصة بالمحتوى التعليمي الذي نقدمه في بطاقاتنا التعليمية من فيديوهات، أوراق عمل واختبارات وغيره .

في هذه الفترة الخاصة بمراجعات "الهيكل" لمادة الفصل الدراسي الأول، نود التأكيد على التالي:

يمنع منعاً باتاً نشر أوراق الشرح المطولة أو تصوير فيديوهات الشرح الخاصة بنا أو إعادة توزيعها بأي شكل من الأشكال إذ يُعتبر نشر أي من هذه المواد دون إذن مسبق مخالفة قانونية، ويعرض الفاعل للمساءلة والملاحقة القانونية، لكن **يسمح فقط** بنشر ملزمة الهيكل (غير المطولة)

نشكركم على تفهمكم وتعاونكم في حماية حقوق الجميع ودعم الأكاديمية في توفير محتوى تعليمي آمن وموثوق.

بطاقة الكيمياء

صف 12 متقدم

شرح أ. طارق محمد



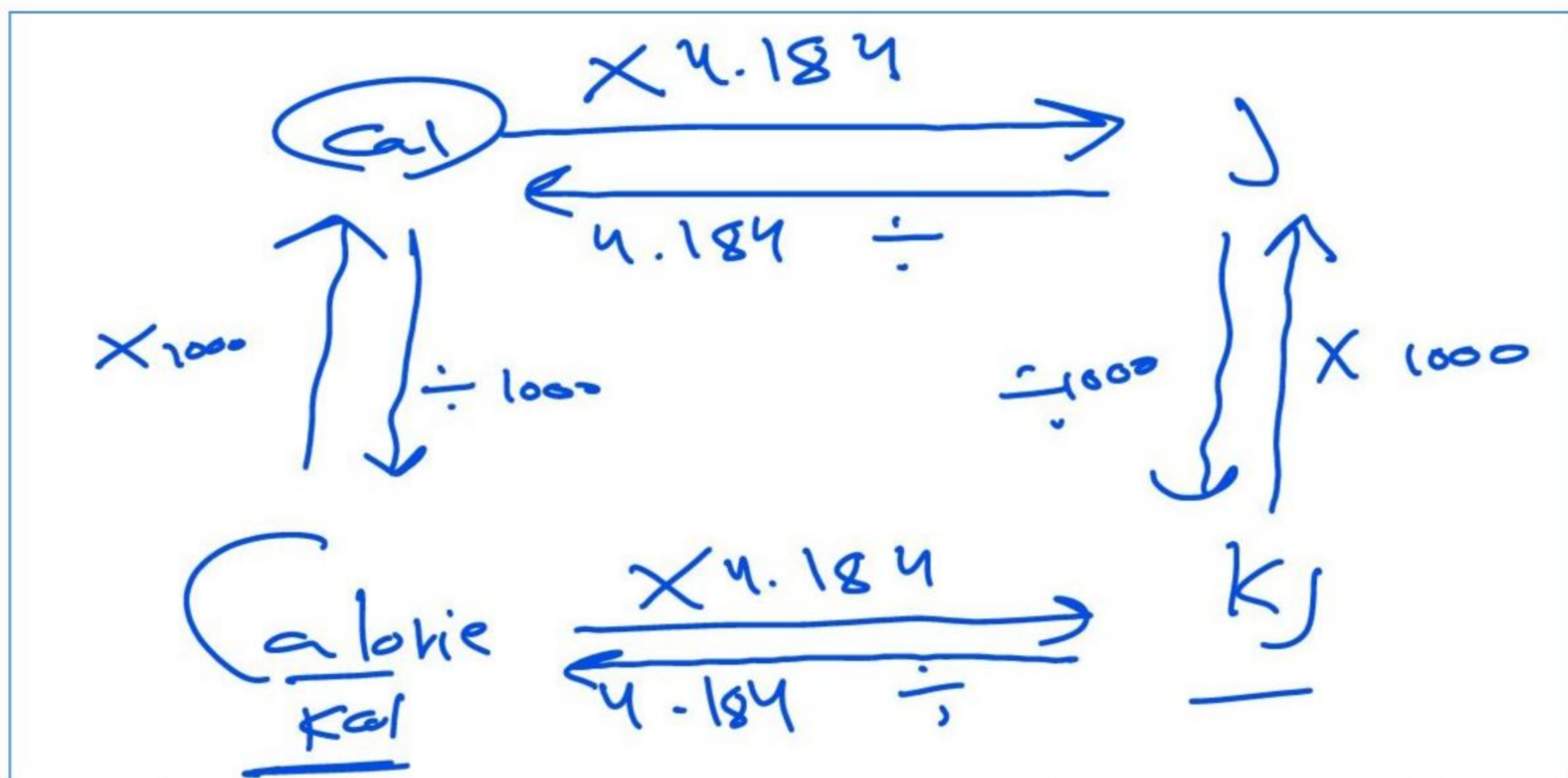
جاهز للنجاح وإطلاق إبداعاتك



فيديوهات ▶ ملازم شرح ▶ أوراق عمل ▶ اختبارات

مراجعة تفصيلية شاملة للهيكل

للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493



A breakfast contains 230 nutritional Calories. Express this energy in joules.

A fruit-and-oatmeal bar contains 142 nutritional Calories. Convert this energy to calories.

An exothermic reaction releases 86.5 kJ. How many kilocalories of energy are released?

CHALLENGE Define a new energy unit, named after yourself, with a magnitude of one-tenth of a calorie. What conversion factors relate this new unit to joules? To Calories?



Extra practice

How many joules are absorbed in a process that absorbs 0.5720 kcal?

Ethanol is being used as an additive to gasoline. The combustion of 1 mol of ethanol releases 1367 kJ of energy. How many Calories are released?

To vaporize 2.00 g of ammonia, 656 calories are required. How many kilojoules are required to vaporize the same mass of ammonia?

One mole of ethanol releases 326.7 Calories of energy during combustion. How many kilojoules are released?





To vaporize 3.00 g of ammonia, 845.5 cal are required. How many kilojoules (kJ) are required to vaporize the same mass of ammonia?

لتبخير 3.00 g من الأمونيا، نحتاج إلى 845.5 cal كم كيلو جول (kJ) يلزم لتبخير نفس الكتلة من الأمونيا؟

2.87

3.54

3.85

2.68

Which of the following statements is true about the two figures in the table below?

أي العبارات التالية صحيحة فيما يتعلق بالشكلين في الجدول أدناه؟

	
150 Cal	5.0×10^5 J
Y	X

The energy in X is greater than in Y

الطاقة في X أكبر منها في Y

The energy in Y is 3.6×10^5 J

الطاقة في Y تساوي 3.6×10^5 J

The energy in X is 355 Cal

الطاقة في X تساوي 355 Cal

The energy in Y is greater than in X

الطاقة في Y أكبر منها في X



2 mole of ethanol releases **653.4 Cal** of energy during combustion. How many kilojoules are released?

يُحرر 2 مول من الإيثانول **653.4 Cal** من الطاقة أثناء الاحتراق. كم كيلو جول يتحرر؟

$$2.734 \times 10^3 \text{ kJ}$$

$$1.350 \times 10^3 \text{ kJ}$$

$$1.600 \times 10^2 \text{ kJ}$$

$$7.800 \times 10^2 \text{ kJ}$$

Which of the following contains **the highest** nutritional Calories?

أي مما يلي يحتوي على أكبر كمية من السعرات الغذائية Cal؟

1000 cal

10 Cal

9600 J

86.5 kJ

How much energy in joules is supplied by a breakfast containing 170 Cal?

ما مقدار الطاقة بوحدة الجول (J) التي تزودنا بها وجبة افطار تحتوي 170 Cal؟

170 J

$7.11 \times 10^5 \text{ J}$

$1.7 \times 10^5 \text{ J}$

711 J



Calculating heat absorbed or released

Equation for Calculating Heat

$$q = c \times m \times \Delta T$$

q represents the heat absorbed or released.

c represents the specific heat of the substance.

m represents the mass of the sample in grams.

ΔT is the change in temperature in $^{\circ}\text{C}$, or $T_{\text{final}} - T_{\text{initial}}$

Note: If heat was released or the substance was cooled then ΔT and q are negative

Practice

If the temperature of 34.4 g of ethanol increases from 25.0°C to 78.8°C , how much heat has been absorbed by the ethanol? (The specific heat of ethanol is $2.44 \text{ J}/(\text{g}^{\circ}\text{C})$)

The temperature of a sample of iron with a mass of 10.0 g changed from 50.4°C to 25.0°C with the release of 114 J. What is the specific heat of iron?

A 155-g sample of an unknown substance was heated from 25.0°C to 40.0°C . In the process, the substance absorbed 5696 J of energy. What is the specific heat of the substance?

Challenge A 4.50-g nugget of pure gold absorbed 276 J of heat. The initial temperature was 25.0°C . What was the final temperature? (The specific heat of gold is $0.129 \text{ J}/(\text{g}^{\circ}\text{C})$)



Calculate the amount of heat absorbed when 5.50 g of aluminum is heated from 25.0°C to 95.0°C. The specific heat of aluminum is 0.897 J/(g·°C).

A 25.0-g bolt made of an alloy absorbed 250 J of heat as its temperature changed from 25.0°C to 78.0°C. What is the specific heat of the alloy?

The specific heat of ethanol is 2.44 J/(g·°C). How many kilojoules of energy are required to heat 50.0 g of ethanol from -20.0°C to 68.0°C?

10.7 kJ

1.22 kJ

8.30 kJ

5.86 kJ

If 250 g of ethanol at 75.0°C loses 4655 J of heat, what is the final temperature of ethanol?
(Specific Heat of ethanol = 2.44 J/ (g. °C)

إذا فقد 250 g من الإيثانول درجة حرارته 75.0°C كمية من الحرارة مقدارها 4655 J . فما درجة الحرارة النهائية للإيثانول؟
(الحرارة النوعية للإيثانول هي 2.44 J/ (g. °C)

45.8°C

59.5°C

82.6°C

67.4°C





A 15.0 g piece of cadmium metal absorbed 32.0 cal of heat. The final temperature was 62.7°C and the specific heat of cadmium equals 0.231 J/(g.°C). What was the initial temperature?

امتصت قطعة كتلتها 15.0 g من فلز الكاديوم 32.0 cal من الحرارة. كانت درجة الحرارة النهائية 62.7°C والحرارة النوعية للكاديوم تساوي 0.231 J/(g.°C) ماذا كانت درجة الحرارة الابتدائية؟

38.7°C

24.1°C

9.3°C

53.4°C

A 355 g sample of unknown substance was heated from 22.4 °C to 43.6 °C the substance piece absorbs 6.75 kJ of energy.

تم تسخين عينة كتلتها 355 g من مادة غير معلومة من 22.4 °C إلى 43.6 °C وامتصت هذه المادة خلال العملية 6.75 kJ من الطاقة.

Using the table below, which is the substance?

مُستخدمًا الجدول أدناه، ما هي المادة؟

Substance	الذهب Gold	الفضة Silver	الألمنيوم Aluminum	الحديد Iron	المادة
Specific heat J/(g.°C)	0.129	0.235	0.897	0.449	الحرارة النوعية J/(g.°C)

Silver

الفضة

Gold

الذهب

Aluminum

الألمنيوم

Iron

الحديد

If 3.00 g of aluminum foil, placed in an oven and heated from 20.0°C to 662.0°C, absorbs 1728 J of heat, what is the specific heat of aluminum?

- A. 0.131 J/g.°C
B. 0.870 J/g.°C
C. 0.897 J/g.°C

- D. 2.61 J/g.°C
E. 0.261 J/g.°C



Specific Heat

The **specific heat** of any substance is the amount of heat required to raise the temperature of one gram of that substance by one degree Celsius.

Ethanol has a specific heat of $2.44 \text{ J/(g}^\circ\text{C)}$. What does this mean?

Substance with high specific heat Water: $4.184 \text{ J/(g}^\circ\text{C)}$	Substance with low specific heat Concrete: $0.84 \text{ J/(g}^\circ\text{C)}$
It requires much energy(gained or lost) to change temperature. Less change in temperature when energy is added or released	It requires less energy(gained or lost) to change temperature. Large change in temperature when energy is added or released

Concrete sidewalks get hot during a sunny summer day. Why?

How would the temperature change of the concrete compare to that of the water over the course of a cool night?

The same amount of heat is added to a 10 g sample of each of the following metals. If each metal is initially at 20.0°C , which metal will reach the highest temperature?

أضيفت نفس كمية الحرارة إلى 10 g من كل عينة من الفلزات التالية. إذا كانت درجة الحرارة الابتدائية لكل فلز هي 20.0°C ، أي الفلزات سوف يصل إلى أعلى درجة حرارة؟

الفلز Metal	الحرارة النوعية Specific Heat
Beryllium البيريليوم	$1.82 \text{ J/(g}^\circ\text{C)}$
Calcium الكالسيوم	$0.653 \text{ J/(g}^\circ\text{C)}$
Copper النحاس	$0.385 \text{ J/(g}^\circ\text{C)}$
Gold الذهب	$0.129 \text{ J/(g}^\circ\text{C)}$



Equal masses of the four metals given in the table below were left to sit in the Sun at the same time and for the same length of time. What is the order of the four metals according to its temperature increase from smallest increase to largest?

تم ترك كتل متساوية من الفلزات الأربعة الواردة في الجدول أدناه في الشمس في نفس الوقت ولنفس الفترة الزمنية. ما ترتيب الفلزات الأربعة وفقاً لزيادة درجة حرارتها من الأقل إلى الأعلى؟

الفلز Metal	المغنيسيوم Magnesium	الرصاص Lead	السترونشيوم Strontium	الكالسيوم Calcium
Specific Heat الحرارة النوعية	1.023	0.129	0.301	0.647
	J / (g.°C)			

The lowest is calcium, then magnesium, then lead, then strontium

الأقل هو الكالسيوم ثم المغنيسيوم ثم الرصاص ثم السترونشيوم

The lowest is magnesium, then calcium, then strontium, then lead

الأقل هو المغنيسيوم ثم الكالسيوم ثم السترونشيوم ثم الرصاص

The lowest is calcium, then strontium, then magnesium, then lead

الأقل هو الكالسيوم ثم السترونشيوم ثم المغنيسيوم ثم الرصاص

The lowest is lead, then strontium, then magnesium, then calcium

الأقل هو الرصاص ثم السترونشيوم ثم المغنيسيوم ثم الكالسيوم

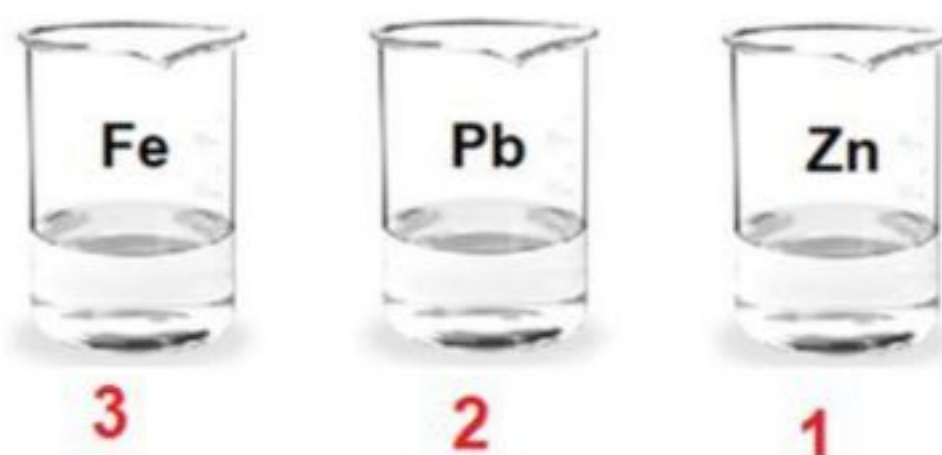
The following table shows specific heat of three metals:

الجدول التالي يوضح الحرارة النوعية لثلاثة فلزات:

Metal	الفلز	Fe	Pb	Zn
specific heat	الحرارة النوعية	0.449 J/(g.°C)	0.129 J/(g.°C)	0.388 J/(g.°C)

If 1.00 g of each metal is heated to 100°C and added to 10.0 g of H₂O at 25°C in the three separate glass beakers as in the figure below,

إذا سُخن 1.00 g من كل فلز إلى 100°C وأضيف إلى 10.0 g من H₂O عند 25°C في ثلاثة كؤوس زجاجية كما في الشكل أدناه،



what is the order of the final temperatures of beakers from the lowest to the highest?

ما ترتيب درجات الحرارة النهائية للكؤوس من الأقل إلى الأعلى؟



A piece of metal with a mass of 4.68 g absorbs 256 J of heat when its temperature increases by 182°C. What is the specific heat of the metal?

A 90.0 g sample of an unknown metal absorbed 25.6 J of heat as its temperature increased 1.18°C. What is the specific heat of the metal?

The temperature of a sample of water increases from 20.0°C to 46.6°C as it absorbs 5650 J of heat. What is the mass of the sample? ($c_{\text{water}} = 4.184 \text{ J/(g}\cdot\text{°C)}$)

How much heat is absorbed by a $2.00 \times 10^3 \text{ g}$ granite boulder ($c_{\text{granite}} = 0.803 \text{ J/(g}\cdot\text{°C)}$) as its temperature changes from 10.0°C to 29.0°C?

Challenge If 335 g of water at 65.5°C loses 9750 J of heat, what is the final temperature of the water?

Calculate the specific heat in $\text{J/(g}\cdot\text{°C)}$ of an unknown substance if a 2.50 g sample releases 12.0 cal as its temperature changes from 25.0°C to 20.0°C.



When 50 g of an unknown substance is placed in 100 g of cold water in a calorimeter, the substance temperature is changes from 168°C to 104°C, while the temperature of the water increased by 1°C. What is the specific heat of the substance?	عند وضع قطعة من مادة غير معلومة ساخنة كتلتها 50 g في 100 g من الماء البارد في مُسعر، تغيّرت درجة حرارة المادة من 168°C إلى 104°C بينما ارتفعت درجة حرارة الماء بمقدار 1 °C ما الحرارة النوعية للمادة؟
Knowing that the specific heat of water at 298 K (25°C) is 4.184 J/(g.°C)	علمًا بأن الحرارة النوعية عند 298k (25°C) للماء تساوي 4.184 J/(g.°C)

How many joules of heat are lost by 3580 kg of granite as it cools from 41.2°C to -12.9°C? The specific heat of granite is 0.803 J/(g · °C).

A swimming pool measuring 20.0 m × 12.5 m is filled with water to a depth of 3.75 m. If the initial temperature is 18.4°C, how much heat must be added to the water to raise its temperature to 29.0°C? Assume that the density of water is 1.000 g/mL.

How much heat is absorbed by a 44.7 g piece of lead when its temperature increases by 65.4°C? The specific heat of lead is 0.129 J/(g · °C).

When 10.2 g of canola oil at 25.0°C is placed in a wok, 3.34 kJ of heat is required to heat it to a temperature of 196.4°C. What is the specific heat of the canola oil?



When a 58.8 g piece of hot alloy is placed in 125 g of cold water in a calorimeter, the temperature of alloy changes from 606.1°C to 500.0°C, while the temperature of water increases by 10.5°C.

عند وضع قطعة من سبيكة ساخنة كتلتها 58.8 g في 125 g من الماء البارد في مُسعر، تغيّرت درجة حرارة السبيكة من 606.1°C إلى 500.0°C بينما ترتفع درجة حرارة الماء بمقدار 10.5°C

What is the **specific heat** of the alloy?

ما الحرارة النوعية لهذه السبيكة؟

Knowing that the specific heat of water at 298 K (25°C) is 4.184 J/(g.°C)

علماً بأن الحرارة النوعية عند 298k (25°C) للماء تساوي 4.184 J/(g.°C)

0.880 J/(g.°C)

1.13 J/(g.°C)

1.02 J/(g.°C)

0.803 J/(g.°C)

When a 75.5 g hot piece of unknown metal is placed in 95.0 g of cold water in a calorimeter, the temperature of the metal decreases by 81.85 °C, while the temperature of water increases by 15.8 °C. What is the specific heat of the metal J/ (g. °C)?

عند وضع قطعة ساخنة من فلز مجهول كتلتها 75.5 g في كالوريمتر يحتوي على 95.0 g من الماء البارد، تقل درجة حرارة الفلز بمقدار 81.85 °C، بينما ترتفع درجة حرارة الماء بمقدار 15.8 °C ما الحرارة النوعية لهذا الفلز بوحدة J/ (g.°C) ؟

The specific heat of water =4.184 J/ (g. °C)

الحرارة النوعية للماء = 4.184 J/(g.°C)

0.449

1.82

0.803

1.02



When a 360 g piece of hot alloy is placed in 425 g of cold water in a calorimeter, the temperature of the alloy decreases by 205°C , while the temperature of the water increases by 18.7°C .

What is the specific heat of the alloy?

Specific heat of water = $4.184 \text{ (J/g}^{\circ}\text{C)}$

عند وضع قطعة من سبيكة ساخنة كتلتها 360 g في 425 g من الماء البارد في مُسعر حراري ، تقل درجة حرارة السبيكة بمقدار 205°C ، بينما تزداد درجة حرارة الماء بمقدار 18.7°C ما الحرارة النوعية لهذه السبيكة؟

الحرارة النوعية للماء = $4.184 \text{ (J/g}^{\circ}\text{C)}$

0.380 J/(g. $^{\circ}\text{C}$)

0.235 J/(g. $^{\circ}\text{C}$)

0.129 J/(g. $^{\circ}\text{C}$)

0.450 J/(g. $^{\circ}\text{C}$)

Two pieces of aluminum and iron were left to sit in the Sun at the same time and for the same length of time. What is the mass of the piece of iron (g) whose temperature increases by the same amount as the piece of aluminum?

ثُركت قطعتان من الألمنيوم والحديد في الشمس في نفس الوقت ولنفس المدة الزمنية، ما كتلة قطعة الحديد (g) التي تزداد درجة حرارتها بنفس مقدار زيادة درجة حرارة قطعة الألمنيوم؟

المادة Substance	الألمنيوم Aluminium	الحديد Iron
الكتلة Mass	47.0 g	
الحرارة النوعية Specific Heat J/(g. $^{\circ}\text{C}$)	0.897	0.449
ΔT	30.0°C	30.0°C

45.6

53.5

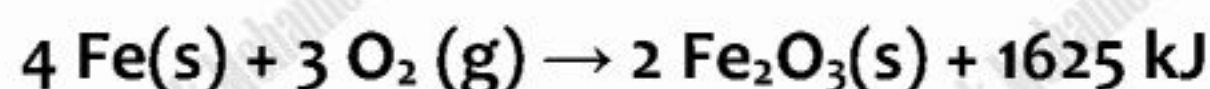
93.9

35.5



Chemical Energy and the Universe

Thermochemistry is the study of heat changes that accompany chemical reactions and phase changes.



Is this reaction exothermic or endothermic? Why?

System	The specific part of the universe that contains the reaction or process.
Surroundings	Everything in the universe other than the system.
Universe	system + surroundings

In heatpack reaction, Heat produced by the reaction flows from the heat pack to your cold hands

So in exothermic reactions, The flow of heat is from the to the

When barium hydroxide and ammonium thiocyanate crystals, shown in the figure, are placed in a beaker and mixed, an **endothermic** reaction occurs.

Figure 7 In this endothermic reaction, the reacting mixture draws enough energy from the water and the wet board to cause the wet board to freeze to the beaker.



In an endothermic reaction or process, The flow of heat is from the

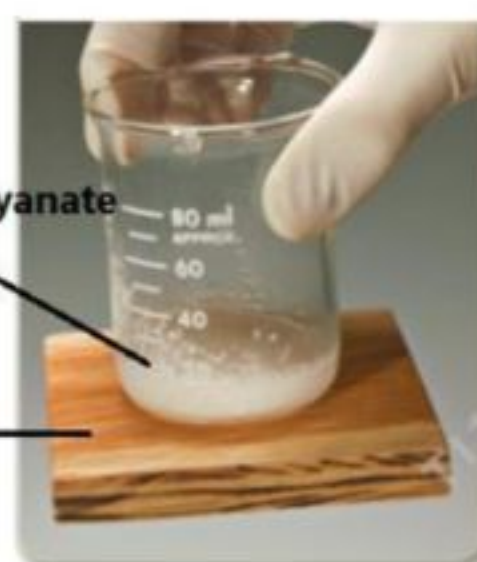
..... to the

In the endothermic reaction shown below,
What is the heat flows direction?

في التفاعل الماص للحرارة الموضح أدناه،
ما اتجاه انتقال الحرارة؟

خليط من هيدروكسيد الباريوم وبلورات ثيوسيانات الأمونيوم
a mixture of barium hydroxide and ammonium thiocyanate crystals

لوح رطب
a wet board



From the beaker to the wet board and water

من الكأس إلى اللوح الرطب والماء

From the wet board and water to the beaker

من اللوح الرطب والماء إلى الكأس

From the mixture to the universe

من الخليط إلى الكون

From the system to the surroundings

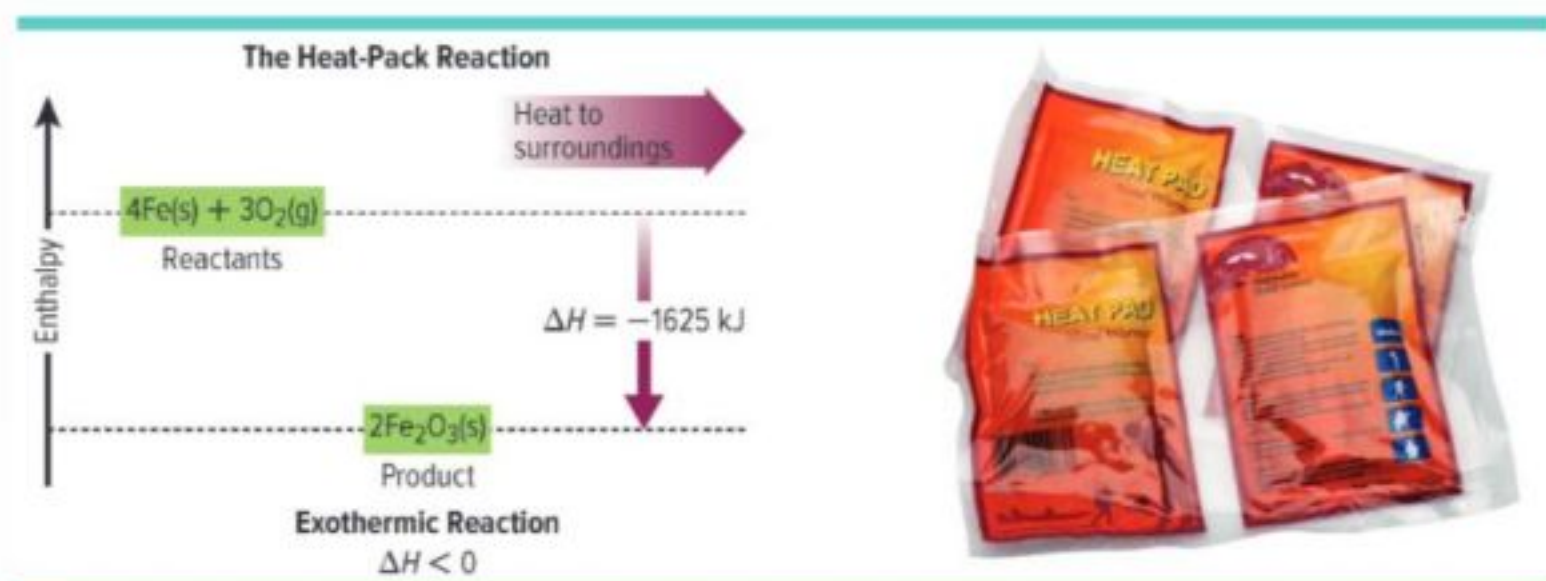
من النظام إلى المحيط



6	CHM.5.5.01.004.03 Identify direction of heat flow (For Exothermic and endothermic processes)	Textbook + figures 8 ,9	15 ,16 , 17
7	CHM.5.5.01.004.04 Compare and contrast potential energy diagrams of exothermic and endothermic reactions in terms of general shape, enthalpy of reactants and products, activation energy of forward and backward reactions, and enthalpy of reaction and its sign	Textbook + figures 8 ,9 + check your progress	15 ,16 , 17 , 22

The sign of the enthalpy of reaction

Exothermic Reactions



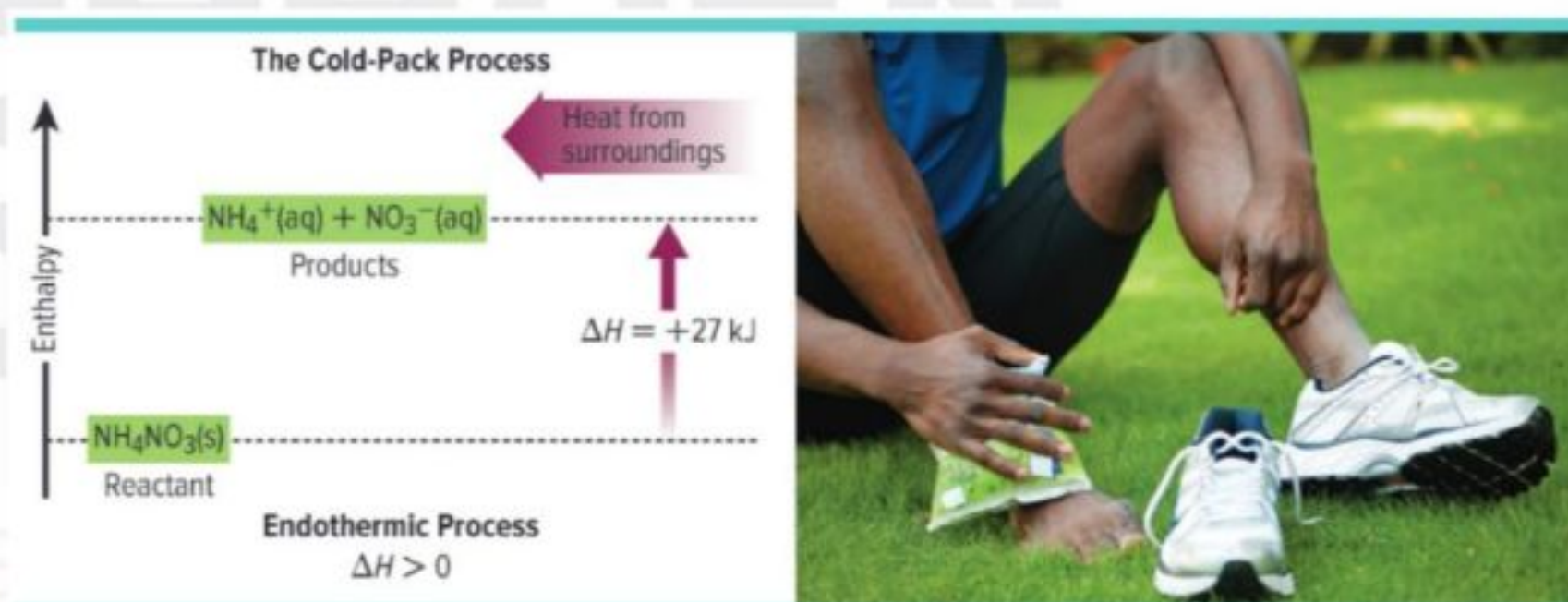
Write the equation for this reaction in two ways.

The downward arrow shows that 1625 KJ of heat is from the
To the

Explain how the diagram shows that the reaction is exothermic.

Explain why ΔH for an exothermic reaction always has a negative value.

Endothermic Reactions



Write the equation for this reaction in two ways.

The upward arrow shows that 27 KJ of heat is from the
To the

In endothermic reactions ΔH_{rxn} always has a Value because

ΔH (the enthalpy change is equal to q_p (the heat gained or lost) at constant pressure.

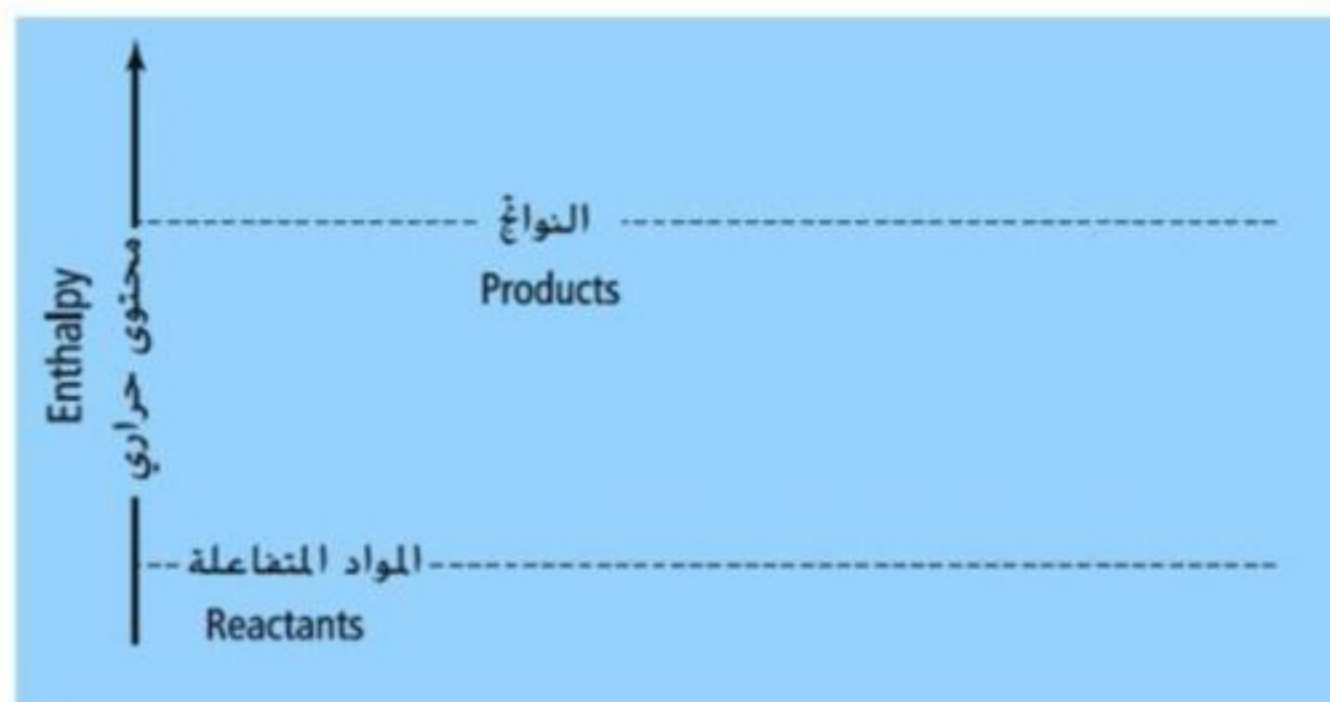




Practice

Which of the following is **correct** regarding the figure below?

أي التالية **صحيح** فيما يتعلق بالشكل أدناه؟



The reaction is an exothermic

التفاعل طارد للحرارة

Heat to surroundings

الحرارة إلى الوسط

Represents the reaction that occur in the Cold-Pack

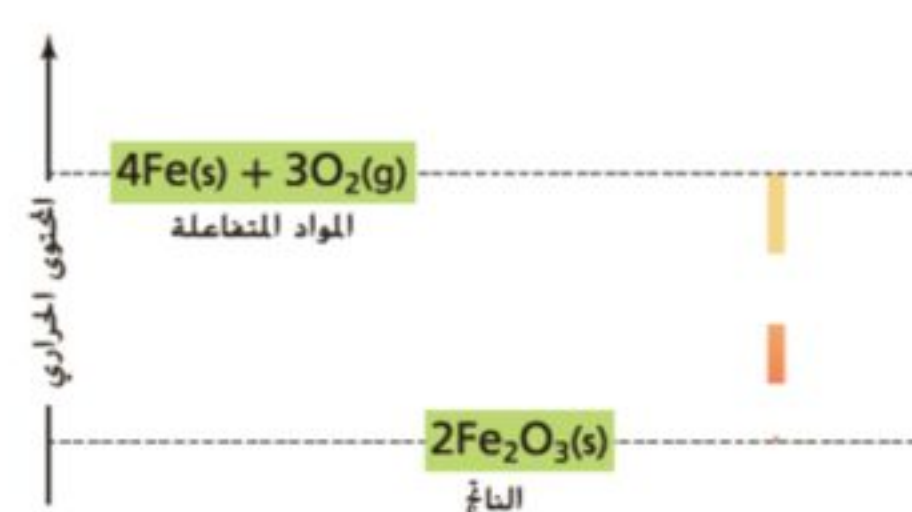
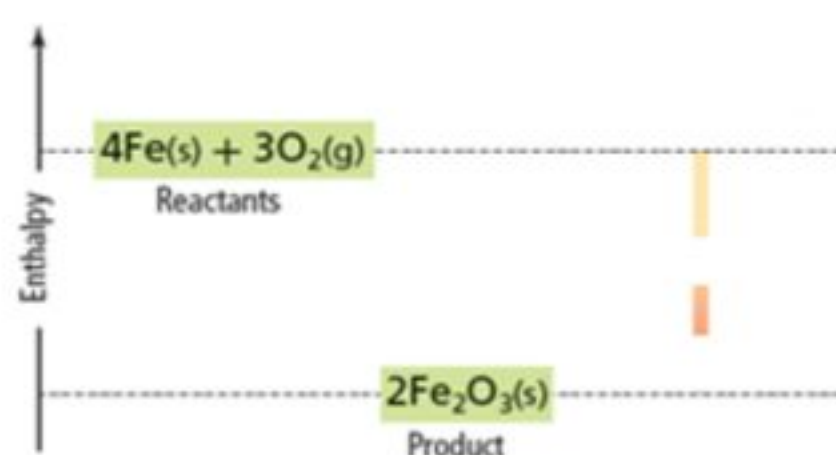
يُمثل التفاعل الذي يحدث في الكمادة الباردة

The enthalpy of the products is less than the enthalpy of the reactants

المحتوى الحراري للنواتج أقل من المحتوى الحراري للمواد المتفاعلة

Which of the following is true regarding the figure below?

أي مما يأتي صحيح فيما يتعلق بالشكل أدناه؟



The sign of enthalpy change is positive

إشارة التغير في المحتوى الحراري موجبة

This reaction is used in the Cold-Pack

يُستخدم هذا التفاعل في الكمادة الباردة

The reaction is endothermic

التفاعل ماص للحرارة

This reaction is used in the Heat-Pack

يُستخدم هذا التفاعل في الكمادة الساخنة

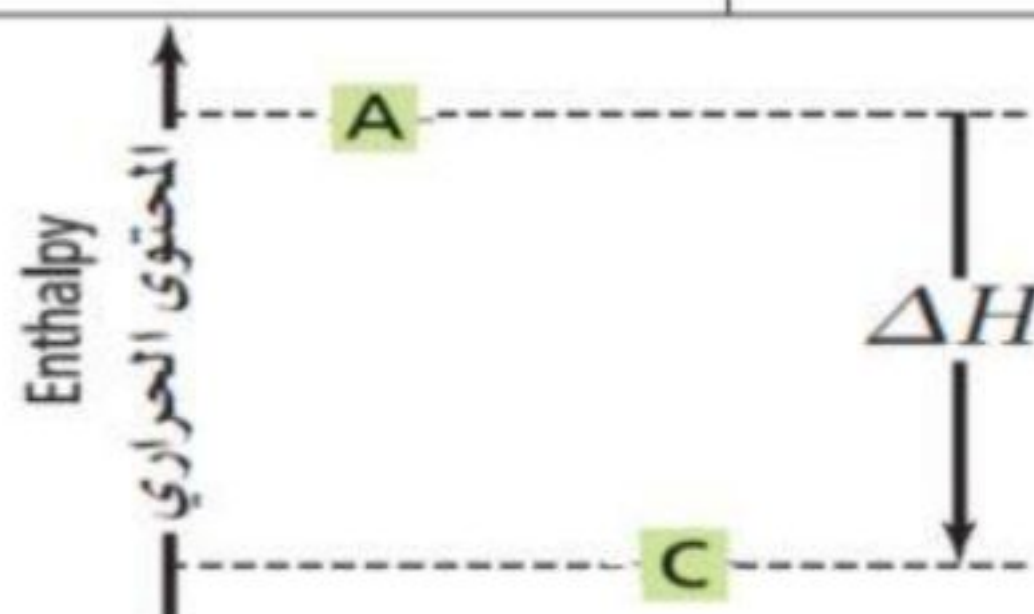


Which of the following is **correct** about the reaction with the equation: $A \rightarrow C$, shown in the diagram below?

أي من التالية **صحيحاً** حول التفاعل ذو المعادلة: $A \rightarrow C$ الموضح بالشكل أدناه؟

I.	$\Delta H > 0$
II.	$H_{\text{products}} < H_{\text{reactants}}$
III.	Heat flows from the system to the surroundings

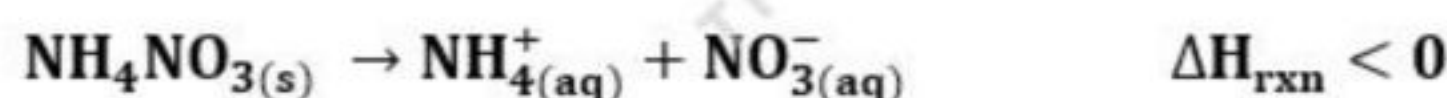
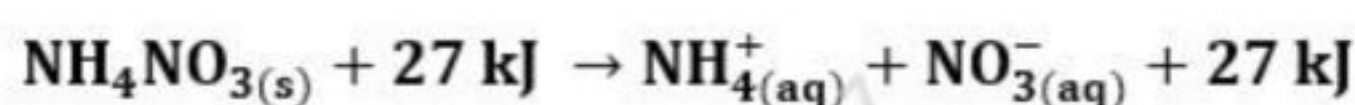
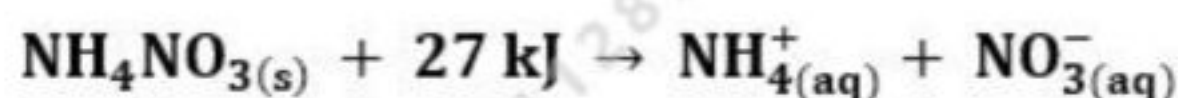
I.	$\Delta H > 0$
II.	$H_{\text{المنتجات}} < H_{\text{المتفاعلات}}$
III.	الحرارة تنتقل من النظام إلى المحيط



A. I only	A. فقط I
B. I and II only	B. I و II فقط
C. II and III only	C. II و III فقط
D. I and III only	D. I و III فقط

Which of the following represents the cold pack process?

أي مما يلي يمثل العملية التي تحدث في الكمادة الباردة؟



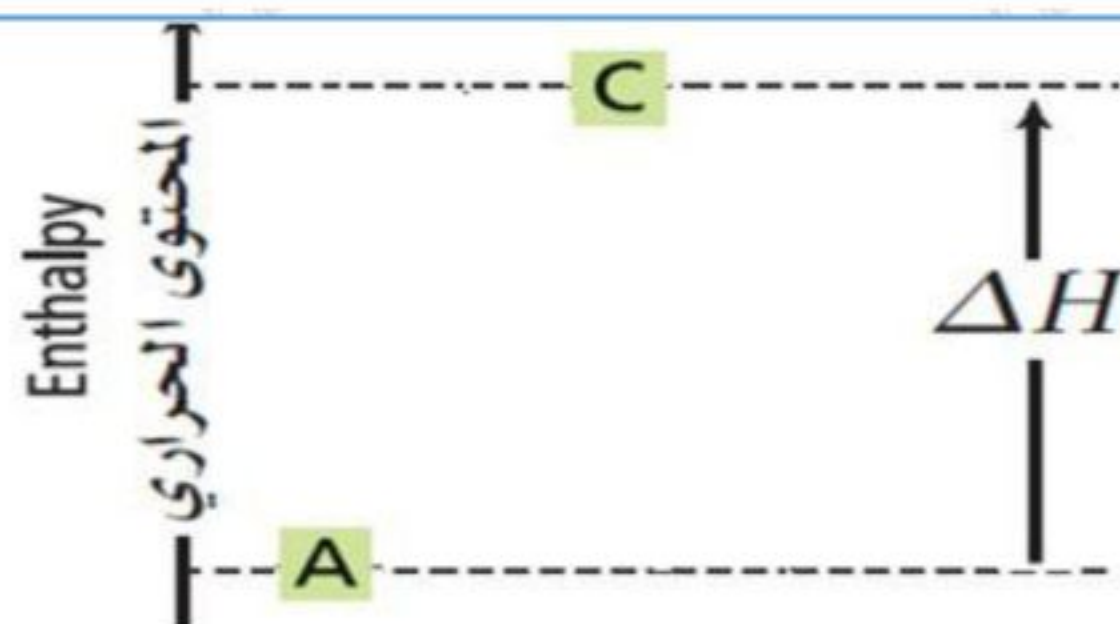


Which of the following is **correct** about the reaction with the equation: $A \rightarrow C$, shown in the diagram below?

أي من التالية **صحيحاً** حول التفاعل ذو المعادلة: $A \rightarrow C$ الموضح بالشكل أدناه؟

I.	$\Delta H > 0$
II.	$H_{\text{products}} < H_{\text{reactants}}$
III.	Heat flows from the surroundings to the system

I.	$\Delta H > 0$
II.	$H_{\text{الناتج}} < H_{\text{المستفاعلات}}$
III.	الحرارة تنتقل من المحيط الى النظام



A. I only

B. I and III only

C. II and III only

D. I and II only

A. فقط I

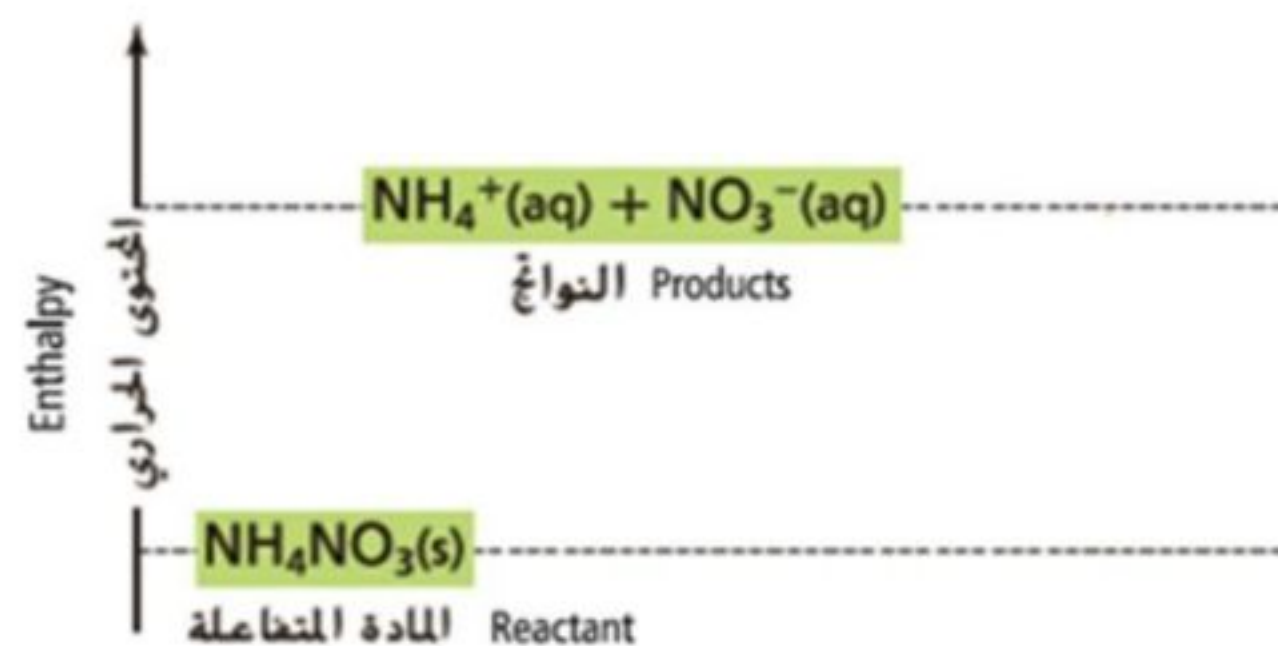
B. I و III فقط

C. II و III فقط

D. I و II فقط

Which of the following is correct regarding the diagram and figures (1) and (2) below?

أي مما يأتي صحيح فيما يتعلق بالرسم البياني والشكلين (1) و (2) أدناه؟



The graph shows that the reaction is exothermic and is used to warm cold hands in figure (1)

يوضح الرسم البياني أن التفاعل طارد للحرارة ويُستخدم لتدفئة اليدين الباردتين في الشكل (1)

The graph shows that the reaction is endothermic and used to warm cold hands in figure (1)

يوضح الرسم البياني أن التفاعل ماص للحرارة ويُستخدم لتدفئة اليدين الباردتين في الشكل (1)

The graph shows that the reaction is endothermic and used to cool the leg of a person in figure (2)

يوضح الرسم البياني أن التفاعل ماص للحرارة ويُستخدم لتبريد ساق الشخص في الشكل (2)

The graph shows that the reaction is exothermic and is used to cool the leg of a person in figure (2)

يوضح الرسم البياني أن التفاعل طارد للحرارة ويُستخدم لتبريد ساق الشخص في الشكل (2)



8	CHM.5.5.01.006.10 Write thermochemical equation for the changes of state (vaporization, fusion, condensation and solidification)	Textbook	19,20
10	CHM.5.5.01.003.04 Define molar enthalpy (heat) of solidification, ΔH_{solid}	Textbook	20

Changes of State

Process	From	To	Endo/Exo	Sign of ΔH
Fusion(melting)				
Vaporization				
Solidification(freezing)				
Condensation				

When you step out of a hot shower, you shiver.

That is because heat is taken from your skin to vaporize the water, you cool down.

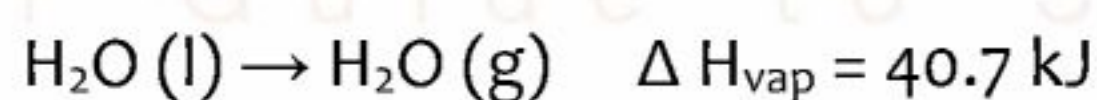
Heat required to vaporize one mole of a liquid is **molar enthalpy (heat) of vaporization** (ΔH_{vap}).

Heat required to melt one mole of a solid substance is **molar enthalpy (heat) of fusion** (ΔH_{fus}).

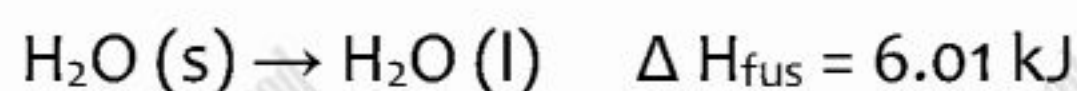
Table 4 Standard Enthalpies of Vaporization and Fusion

Substance	Formula	$\Delta H_{\text{vap}}^{\circ}$ (kJ/mol)	$\Delta H_{\text{fus}}^{\circ}$ (kJ/mol)
Water	H_2O	40.7	6.01
Ethanol	$\text{C}_2\text{H}_5\text{OH}$	38.6	4.94
Methanol	CH_3OH	35.2	3.22
Acetic acid	CH_3COOH	23.4	11.7
Ammonia	NH_3	23.3	5.66

Thermochemical equations for changes of state



This equation indicates that



This equation indicates that

Write the thermochemical equations of condensation and solidification of water.

Condensation:

Solidification:



$(\Delta H_{\text{vap}} = -\Delta H_{\text{cond}})$ means that they have similar
and different
 $(\Delta H_{\text{fus}} = -\Delta H_{\text{solid}})$ means that they have similar
and different

Farmers make use of the heat of fusion of water to protect fruit and vegetables from freezing.

If the temperature is predicted to drop to freezing, they flood their fields with water.

When the water freezes, energy (ΔH_{fus}) is released and often warms the surrounding air enough to prevent frost damage.

Questions about figure 10:

Which state of matter has the highest energy(enthalpy)?

.....

Which state of matter has the lowest energy(enthalpy)?

.....

Draw a quick diagram to help you memorize the graph

Phase Changes for Water

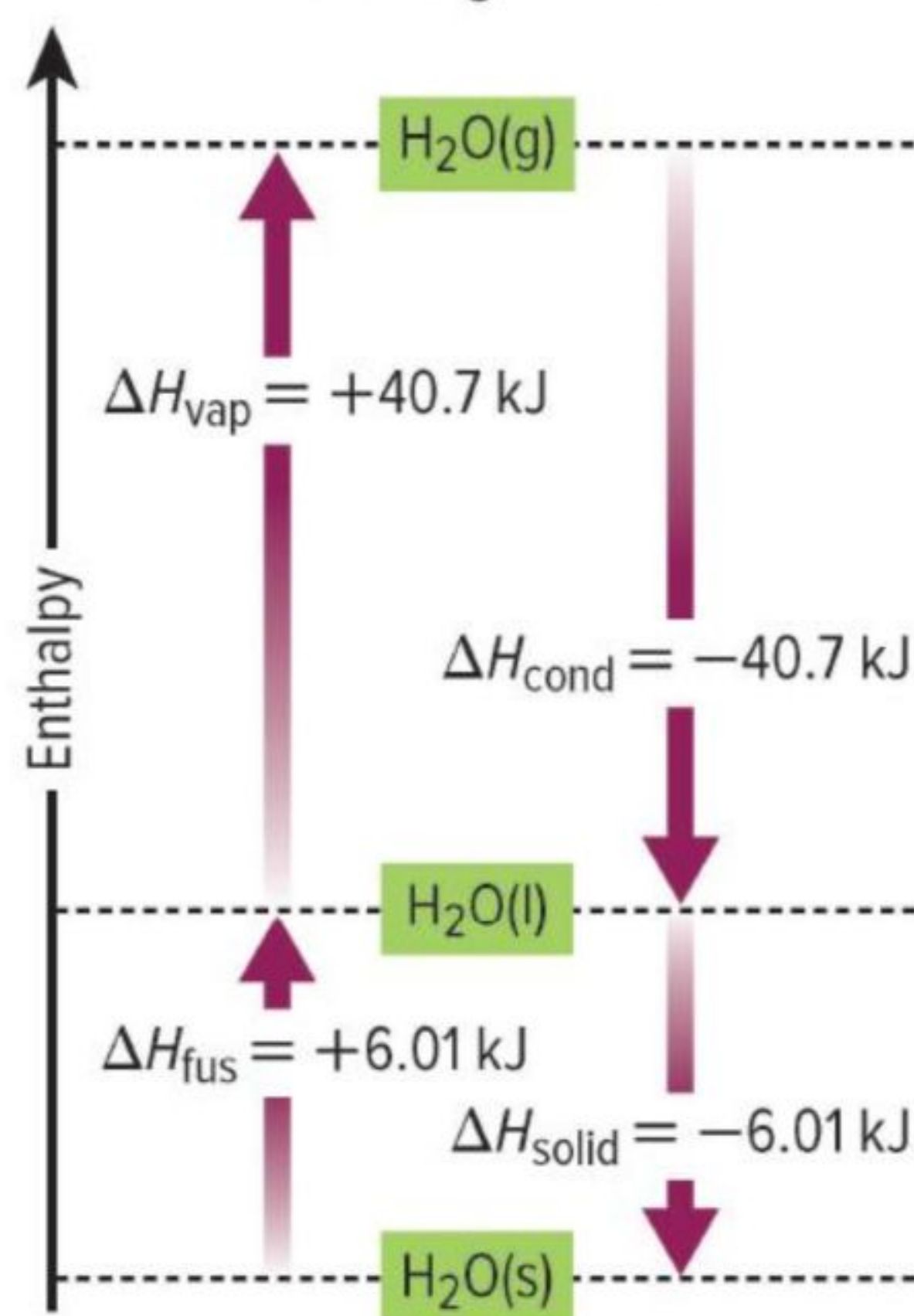


Figure 10 The upward arrows show that the energy of the system increases as ice melts and then vaporizes. The downward arrows show that the energy of the system decreases as water vapor condenses and then solidifies.

Which of the following processes have ΔH positive values?

أي العمليات التالية تكون قيم ΔH لها موجبة؟

I	$\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$
II	$\text{H}_2\text{O}_{(s)} \rightarrow \text{H}_2\text{O}_{(l)}$
III	$\text{H}_2\text{O}_{(g)} \rightarrow \text{H}_2\text{O}_{(l)}$
IV	$\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(s)}$

I and II

I و II

I and III

I و III

III and IV

III و IV

II and IV

II و IV





Which of the data in the following table is correct?

أي من البيانات الواردة في الجدول التالي صحيحة؟

الرقم Number	العملية Process	التغير في المحتوى الحراري The change in enthalpy	إشارة التغير في المحتوى الحراري The sign of the enthalpy change
1	$C_2H_5OH(s) \rightarrow C_2H_5OH(l)$	طاردة للحرارة exothermic	موجبة positive
2	$NH_3(l) \rightarrow NH_3(s)$	ماصة للحرارة endothermic	موجبة positive
3	$CH_3OH(l) \rightarrow CH_3OH(g)$	ماصة للحرارة endothermic	سالبة negative
4	$H_2O(g) \rightarrow H_2O(l)$	طاردة للحرارة exothermic	سالبة negative

1 only

1 فقط

3 , 4

3 و 4

1 , 2

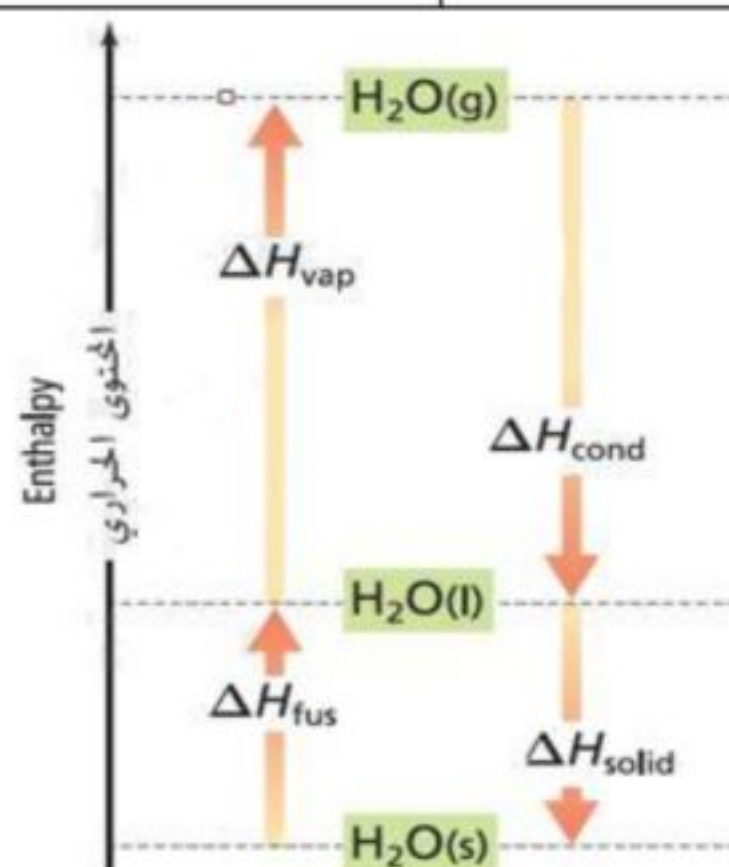
1 و 2

4 only

4 فقط

Which of the following statement is **correct** according to the diagram shown below?

أي العبارات التالية **صحيحة** اعتمادًا على الشكل أدناه؟



- A. The system energy decreases as ice melts and then evaporates
- B. The system energy increases as water vapor condenses and then solidifies
- C. The vaporization of water and melting of ice are considered as exothermic process
- D. The condensation and solidification of water are considered as exothermic process

A. تقل طاقة النظام عند انصهار الثلج ثم تبخره

B. تزيد طاقة النظام عند تكثف بخار الماء ثم تجمده

C. تعتبر عمليات تبخر الماء وصهر الثلج عمليات طاردة للحرارة

D. تعتبر عمليات تكثف الماء وتجمده طاردة للحرارة



Which of the following statements is true regarding the changes below?

أي العبارات التالية صحيحة فيما يتعلق بالتغيرات أدناه؟

1	$C_2H_5OH(l) \rightarrow C_2H_5OH(g)$
2	$NH_3(g) \rightarrow NH_3(l)$
3	$Br_2(l) \rightarrow Br_2(s)$
4	$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

Change 3 is endothermic

التغير 3 ماص للحرارة

In change 1, heat flows from the system to the surroundings

في التغير 1 تنتقل الحرارة من النظام إلى الوسط المحيط

Change 4 is exothermic

التغير 4 طارد للحرارة

In change 2, heat flows from the surroundings to the system

في التغير 2 تنتقل الحرارة من الوسط المحيط إلى النظام

Which of the following processes are **endothermic**?

أي العمليات التالية **ماصة للحرارة**؟

1	$C_2H_5OH(l) \rightarrow C_2H_5OH(g)$
2	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) + 891 \text{ kJ}$
3	$H_2O(s) \rightarrow H_2O(l)$
4	$NaCl(s) \rightarrow NaCl(l)$
5	$H_2O(g) \rightarrow H_2O(l)$

1,3 and 4

1 ، 3 و 4

2,3 and 5

2 ، 3 و 5

3,4 and 5

3 ، 4 و 5

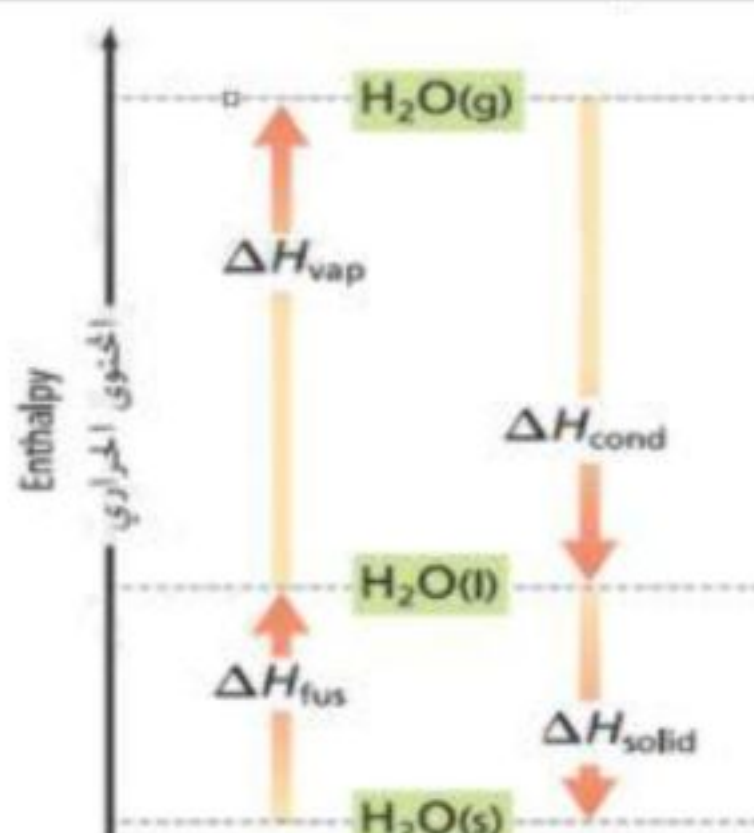
1,2 and 4

1 ، 2 و 4



Which of the following statements is **not correct** according to the diagram shown below?

أي العبارات التالية **غير صحيحة** اعتمادًا على الشكل أدناه؟



A. The ΔH values of the molar enthalpy of vaporization and the molar enthalpy of fusion **are positive**

A. تكون قيم ΔH للحرارة المولية للتبخير والحرارة المولية للانصهار **موجبة**

B. The ΔH values of the molar enthalpy of condensation and molar enthalpy of solidification **are negative**

B. تكون قيم ΔH للحرارة المولية للتكثيف والحرارة المولية للتجمد **سالبة**

C. The molar enthalpy of solidification and the molar enthalpy of fusion have **the same numerical values but with opposite signs**

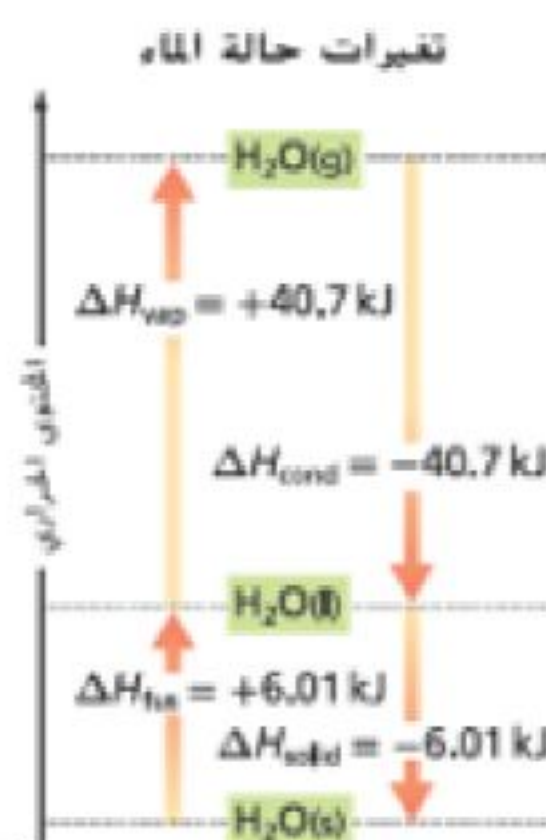
C. تتساوى القيمة العددية للحرارة المولية للتجمد مع القيمة العددية للحرارة المولية للانصهار ولكن **تختلف إشارتهما**

D. The molar enthalpy of condensation and the molar enthalpy of vaporization have **the same numerical values with same sign**

D. تتساوى القيمة العددية للحرارة المولية للتكثيف مع القيمة العددية للحرارة المولية للتبخير **وتتشابه إشارتهما**

In the below figure. The upward arrows show that.....

في الشكل أدناه تشير الأسهم المتجهة إلى الأعلى إلى



A. the energy of the system increases as ice melts and then vaporizes

A. زيادة طاقة النظام عند انصهار الثلج ثم تبخره بعد ذلك

B. the energy of the system decreases as ice melts and then vaporizes

B. انخفاض طاقة النظام عند انصهار الثلج ثم تبخره بعد ذلك

C. the energy of the system increases as water vapor condenses and the solidifies (freezes).

C. زيادة طاقة النظام عند تكثف بخار الماء ثم تجمده بعد ذلك

D. the energy of the system doesn't change

D. عدم تغير طاقة النظام

بطاقة الكيمياء

صف 12 متقدم

شرح أ. طارق محمد



جاهز للنجاح وإطلاق إبداعاتك



فيديوهات ▶ ملازم شرح ▶ أوراق عمل ▶ اختبارات

مراجعة تفصيلية شاملة للهيكل

للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493



Practice Problems_Changes in states

Calculate the heat required to melt 25.7 g of solid methanol at its melting point.

($\Delta H_{\text{fus}}^\circ = 3.22 \text{ kJ/mol}$, molar mass = 32.04 g/mol)

How much heat evolves when 275 g of ammonia gas condenses to a liquid at its boiling point?

($\Delta H_{\text{cond}}^\circ = 23.3 \text{ kJ/mol}$, molar mass = 17.031 g/mol)

The molar heat of vaporization of ammonia is 23.3 kJ/mol. What is the molar heat of condensation of ammonia?

Water is sprayed on oranges during a frosty night. If an average of **29.5 g** of water freezes on each orange, how much heat is released?

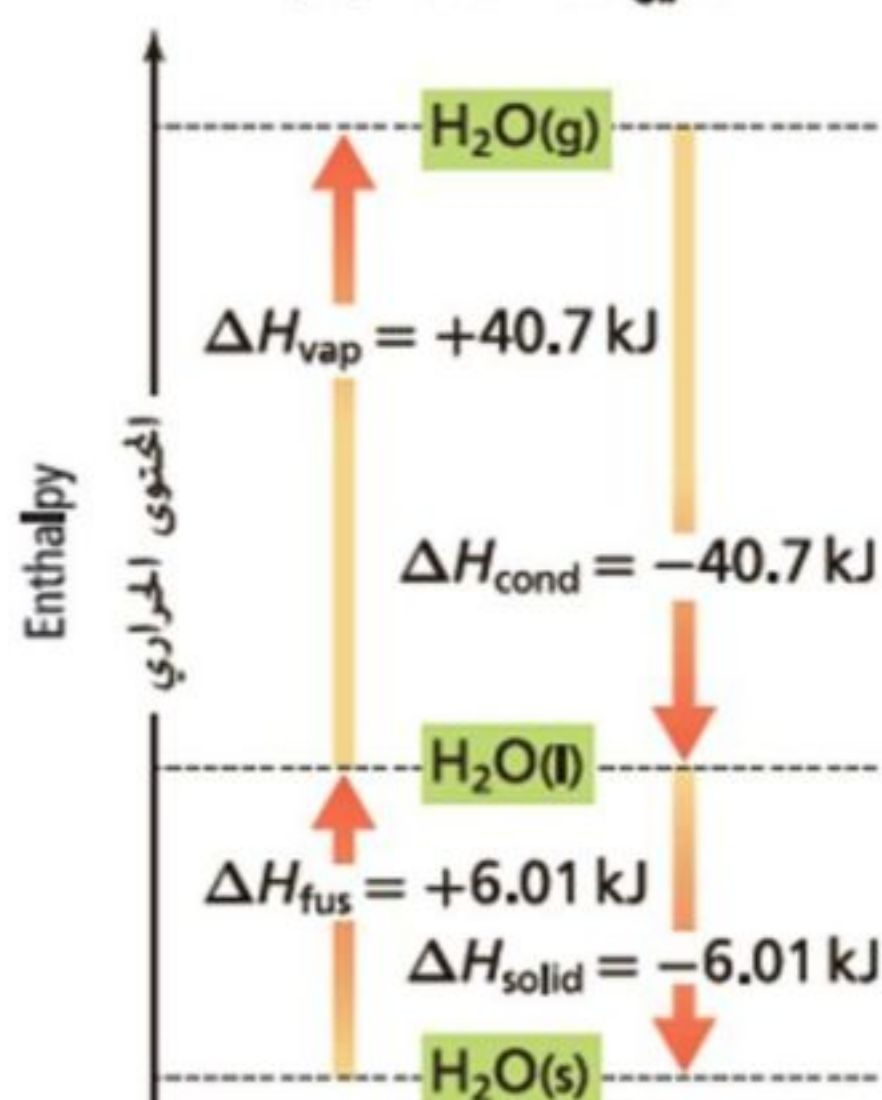
يتم رش الماء على البرتقال خلال الليالي الباردة. إذا كان متوسط مقدار الماء الذي يتجمد على كل برتقالة هو **29.5 g** فما كمية الحرارة الناتجة؟

(الكتلة المولية للماء = 18.02 g/mol)

(molar mass of water = 18.02 g/mol)

Phase Changes for Water

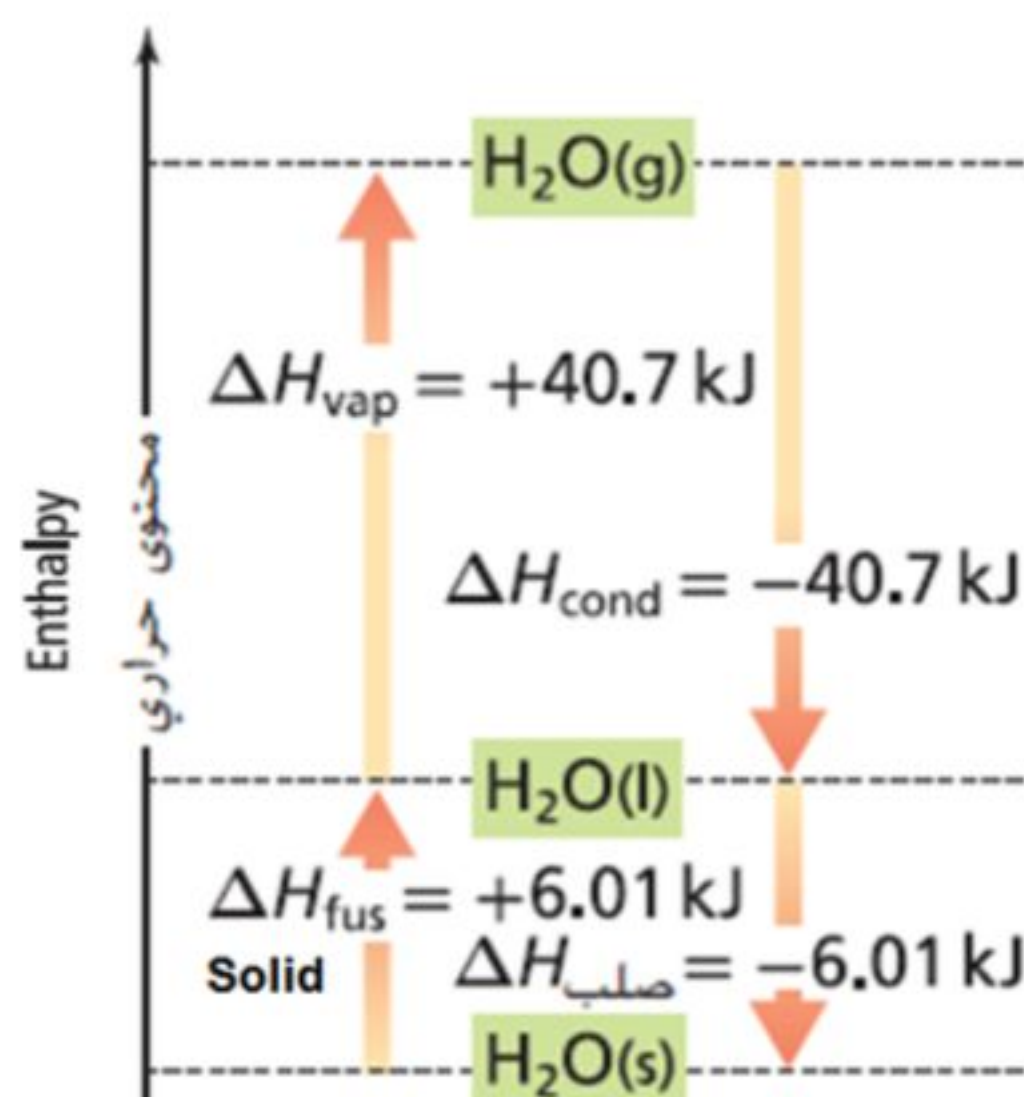
تغيرات حالة الماء





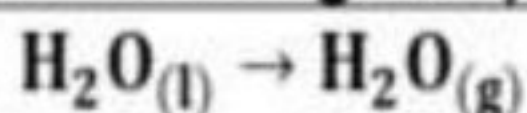
Using the figure below, how much heat in (kJ) is required to evaporate 156.1 g of water at 100°C?
(The molar mass of water is 18.02 g/mol)

موظفًا الشكل أدناه، ما كمية الحرارة بوحدة (kJ) اللازمة لتبخير 156.1 g من الماء عند درجة حرارة 100°C؟
(الكتلة المولية للماء تساوي 18.02 g/mol)



How much heat is required to vaporize 63.07 g of water at 100 °C according to the equation shown below?
(Molar mass of water = 18.02 g/mol)

ما كمية الحرارة اللازمة لتبخير 63.07 g من الماء عند درجة حرارة 100 °C وفقاً للمعادلة أدناه؟
(الكتلة المولية للماء = 18.02 g/mol)



$$\Delta H_{\text{vap}} = + 40.7 \text{ kJ/mol}$$

$$- 102.6 \text{ kJ}$$

$$+ 81.2 \text{ kJ}$$

$$- 122.7 \text{ kJ}$$

$$+ 142.5 \text{ kJ}$$

Calculate the heat required to melt 64.0 g of solid methanol, given that the molar enthalpy of fusion is 3.22 kJ/mol and the molar mass of methanol is 32.0 g.

احسب الحرارة اللازمة لصبهر 64g من الميثانول الصلب، علماً بأن الحرارة المولية لانصهار الميثانول = 3.22 kJ/mol والكتلة الجزيئية للميثانول هي 32.0 g.

$$\text{A. } 3.22 \text{ kJ}$$

$$\text{B. } 6.44 \text{ kJ}$$

$$\text{C. } 9.66 \text{ kJ}$$

$$\text{D. } 12.88 \text{ kJ}$$



If molar enthalpy of vaporization of ethanol is 38.6 kJ/mol, how many moles of ethanol are vaporized, when the required heat is 200.72 kJ?

إذا كان المحتوى الحراري لتبخير الإيثانول = 38.6 kJ/mol ، فما هو عدد مولات الإيثانول المتبخرة عندما تكون الحرارة المطلوبة هي 200.72 kJ/mol ؟

A. 2.60 mol

B. 10.40 mol

C. 1.30 mol

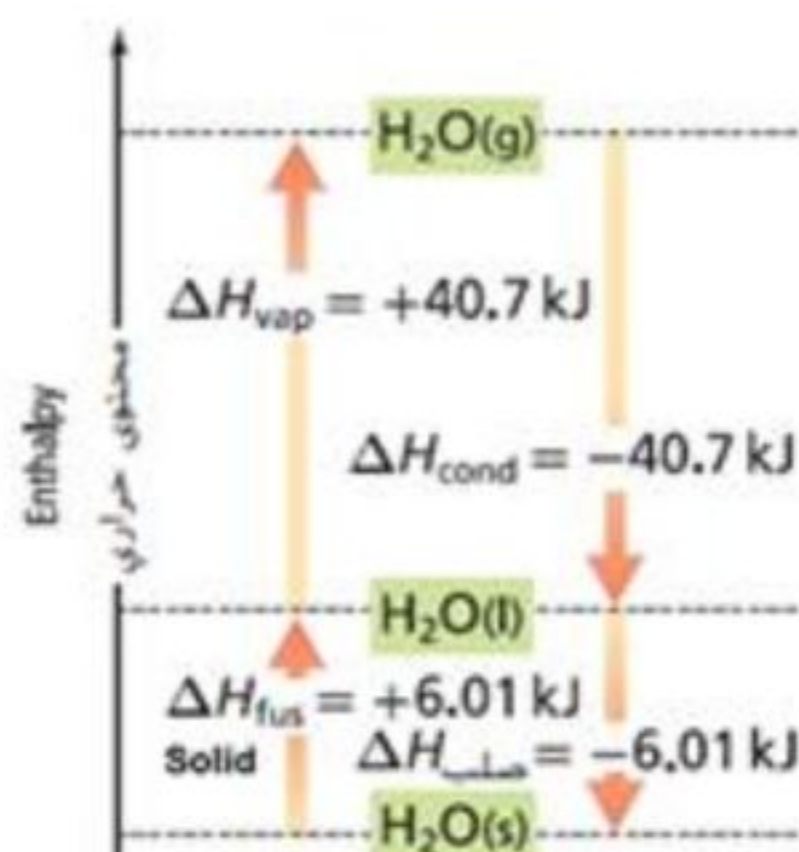
D. 5.20 mol

Using the figure below, how much heat in (kJ) is released in freezing 229.8 g of water?

موظفًا الشكل أدناه، ما كمية الحرارة بوحدة (kJ) الناتجة عن تجمد 229.8 g من الماء؟

(The molar mass of water is 18.02 g/mol)

(الكتلة المولية للماء تساوي 18.02 g/mol)



85.40

68.50

47.30

76.60

Your Guide to Success

Tarek Mohamed

Tarek Mohamed

Tarek Mohamed

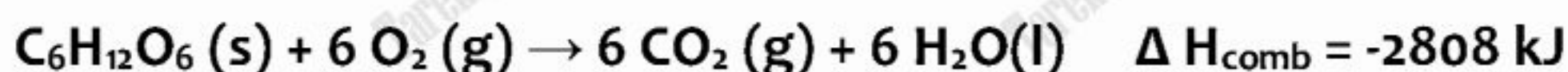
Tarek Mohamed



Combustion Practice Problems

How much heat is evolved when 54.0 g glucose ($C_6H_{12}O_6$) is burned according to this equation?

(The molar mass of glucose = 180.18 g/mol)



What mass of methane (CH_4) must be burned in order to liberate 12,880 kJ of heat?

($\Delta H_{comb}^\circ = -891 \text{ kJ/mol}$) (molar mass=16.04 g/mol)

Calculate how much heat is released by the combustion of 206 g of hydrogen gas. $\Delta H_{comb} = -286 \text{ kJ/mol}$

molar mass of $H_2 = 2 \text{ g/mol}$

Grilling What mass of propane (C_3H_8) must be burned in a barbecue grill to release 4560 kJ of heat? The ΔH_{comb} of propane is -2219 kJ/mol .

molar mass of $C_3H_8 = 44 \text{ g/mol}$





Heating with Coal How much heat is liberated when 5.00 kg of coal is burned if the coal is 96.2% carbon by mass and the other materials in the coal do not react? ΔH_{comb} of carbon is -394 kJ/mol .

molar mass of Carbon = 12 g/mol

What mass of sucrose $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ must be burned in order to liberate **8466 kJ** of heat?

ما كتلة السكروز $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ التي يجب حرقها لإنتاج **8466 kJ** من الحرارة؟

Molar mass	الكتلة المولية	$\Delta H_{\text{comb}}^\circ$	Formula	الصيغة	Substance	المادة
342.3 g/mol		-5644 kJ/mol	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$		Sucrose	السكروز

513.5 g

228.2 g

684.6 g

171.1 g



What mass of methane CH_4 must be burned in order to liberate 10,692 kJ of heat?

ما كتلة الميثان CH_4 التي يجب حرقها لإنتاج 10,692 kJ من الحرارة؟

Molar mass الكتلة المولية	$\Delta H_{comb}^\circ (kJ/mol)$	Formula الصيغة	Substance المادة
16.04 g/mol	-891	CH_4	methane الميثان

385 g

1.37 g

192 g

96.3 g

A fuel releases 1684.8 kJ of heat when 0.600 mol

يُطلق وقود 1684.8 kJ من الحرارة عند احتراق 0.600 mol

of it is burned. Which of the substances listed in

منه. أي أنواع المواد المدرجة في الجدول التالي تمثل هذا الوقود؟

the following table represents this fuel?

Substance المادة	chemical formula الصيغة الكيميائية	$\Delta H_{comb}^\circ (kJ/mol)$
Sucrose السكروز	$\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s})$	-5644
Octane الأوكتان	$\text{C}_8\text{H}_{18}(\text{l})$	-5471
Glucose الجلوكوز	$\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$	-2808
Propane البروبان	$\text{C}_3\text{H}_8(\text{g})$	-2219

Sucrose

السكروز

Octane

الأوكتان

Glucose

الجلوكوز

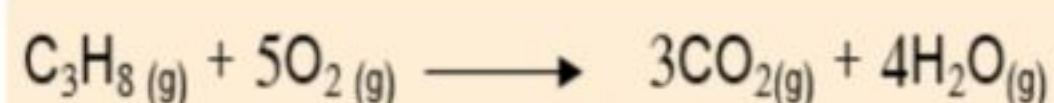
Propane

البروبان



What mass of propane (C_3H_8) in unit (g) is burned to release 9985.5 kJ of heat?

ما كتلة البروبان (C_3H_8) بوحدة (g) التي يتم حرقها لإنتاج 9985.5 kJ من الحرارة؟



The enthalpy (heat) of combustion of propane

$$\Delta H_{comb}^{\circ} = -2219 \text{ kJ/mol}$$

(Molar mass of propane is 44.097 g/mol)

(حرارة احتراق البروبان ΔH_{comb}° هي -2219 kJ/mol)

والكتلة المولية للبروبان 44.097 g/mol)

110.3

198.0

154.4

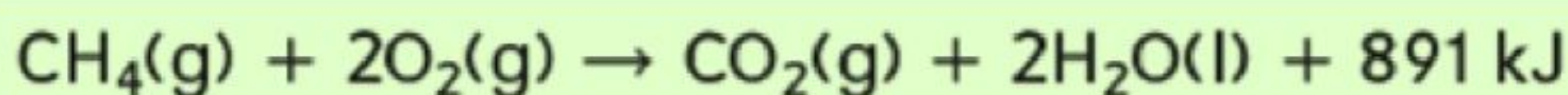
66.20

Using the equation below, how much heat ΔH_{comb} is released by burning 154 g of CH_4 methane?

(Molar mass of methane is 16.04 g/mol)

موظفًا المعادلة أدناه، ما كمية الحرارة الناتجة ΔH_{comb} عن احتراق 154 g من الميثان CH_4 ؟

(الكتلة المولية للميثان هي 16.04 g/mol)



$5.20 \times 10^3 \text{ kJ}$

$6.70 \times 10^3 \text{ kJ}$

$4.50 \times 10^3 \text{ kJ}$

$8.60 \times 10^3 \text{ kJ}$





12	CHM.5.5.02.002.01 Calculate, using Hess's law, the ΔH of a reaction	Textbook + Example problem 5 + Practice problems	23 , 24 , 25 , 26
14	CHM.5.5.02.001.01 State Hess's Law - CHM.5.5.02.001.02 Describe the rules to be followed to apply Hess's Law	Textbook	23

Hess's Law

Sometimes it is impossible or impractical to measure the ΔH of a reaction by using a calorimeter.



This reaction occurs so slowly that measuring the enthalpy change is impossible.

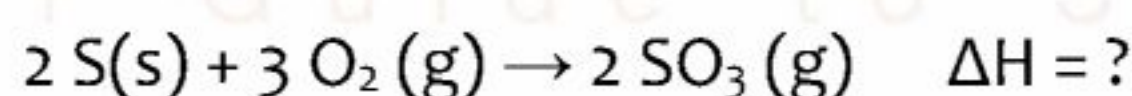


Figure 12 The expression “diamonds are forever” suggests the durability of diamonds and tells you that the conversion of diamond to graphite is so slow that it would be impossible to measure its enthalpy change.

Chemists use a **theoretical way** to determine ΔH when:

- 1- The reaction is too **slow**.
- 2- The reaction occurs under **conditions** difficult to duplicate in a laboratory.
- 3- The reaction produces **products other than the desired ones**.

Example:



Laboratory experiments to produce sulfur trioxide and determine its ΔH result in a different product (SO_2). It should be calculated by using Hess's law of heat summation.

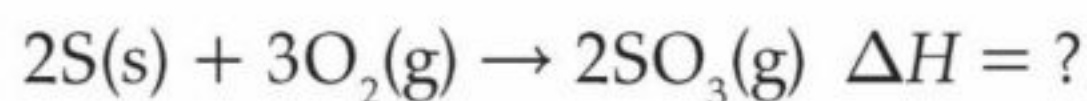
Hess's law

If you can add two or more thermochemical equations to produce a final equation for a reaction, then the sum of the enthalpy changes for the individual reactions is the enthalpy change for the final reaction.

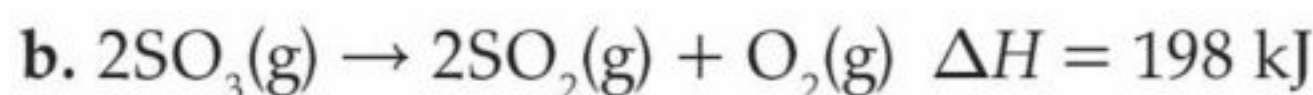
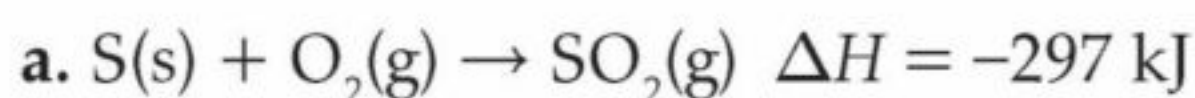


Applying Hess's Law

How can Hess's law be used to calculate the energy change for the reaction that produces SO_3 ?



You will use the following equations containing the substances S , O_2 and SO_3 .

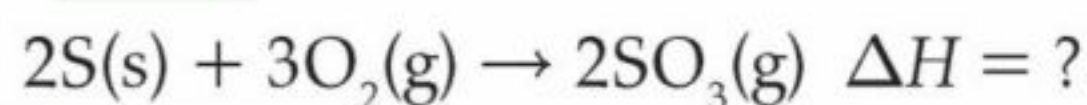


Give numbers to the substances in the desired equation.

1

2

3



Find substance 1 in equation a or b then do the required change in direction or the number of moles.

What change is required?

Find substance 2 in equation a or b then do the required change in direction or the number of moles.

Note: you must skip substance 2 here. Why?

Find substance 3 in equation a or b then do the required change in direction or the number of moles.

What change is required?

Add equations after change, ΔH values. Cancel any terms that are common to both sides of the combined equation.



The Synthesis of Sulfur Trioxide

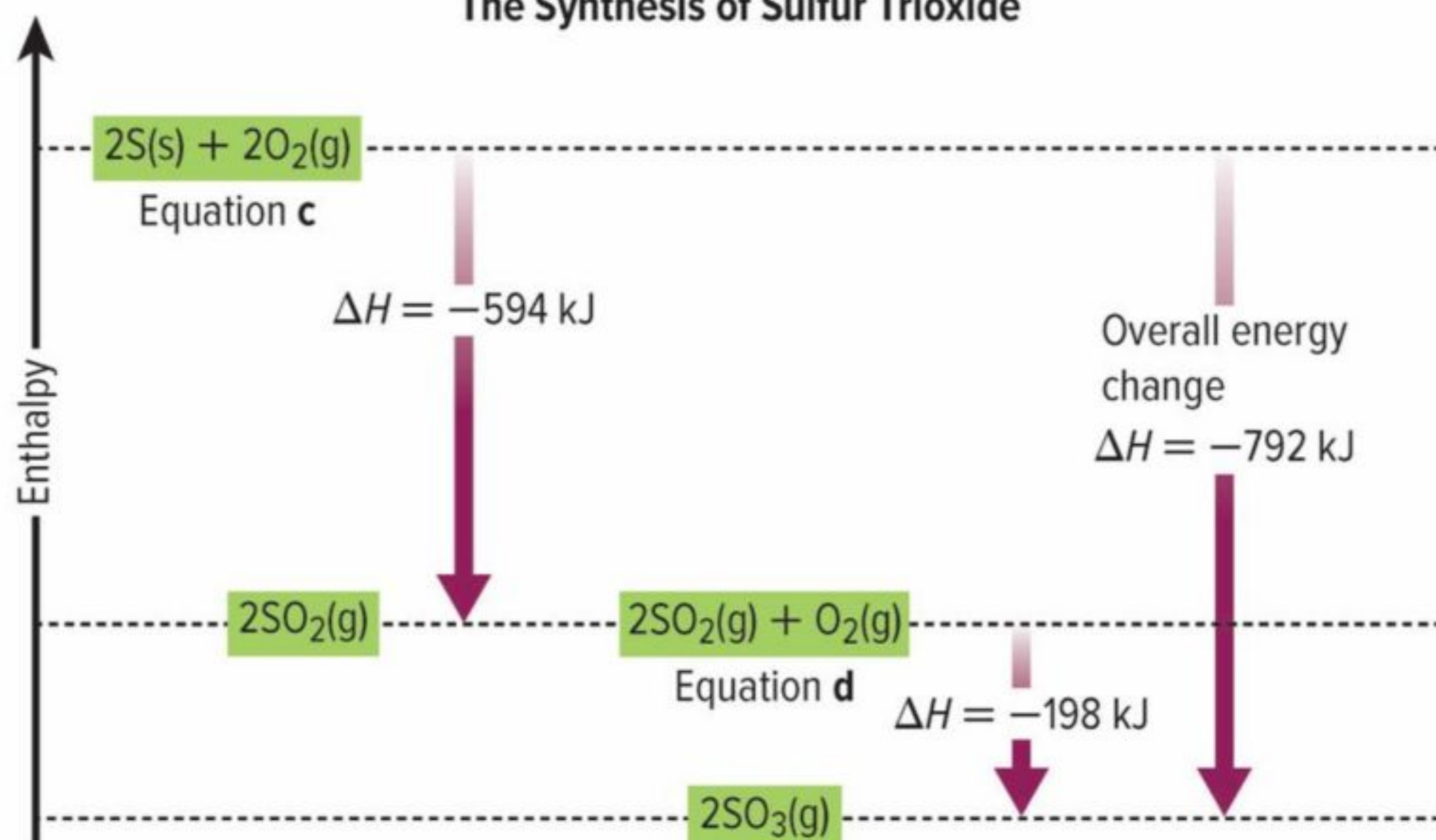


Figure 13 The arrow on the left indicates the release of 594 kJ as S and O₂ react to form SO₂ (Equation c). Then, SO₂ and O₂ react to form SO₃ (Equation d) with the release of 198 kJ (middle arrow). The overall energy change (the sum of the two processes) is shown by the arrow on the right.

Determine the enthalpy change for the decomposition of SO₃ to form S and O₂.

Use the diagram to write the overall equation.

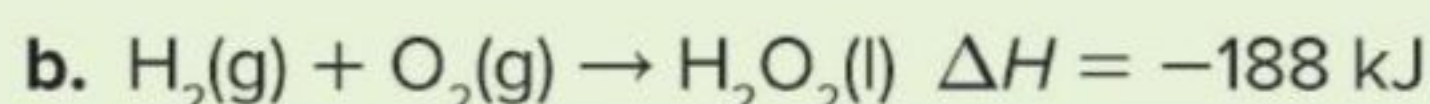
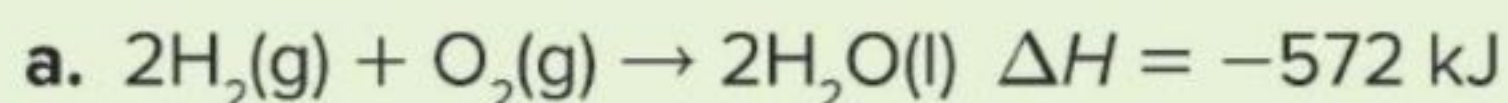
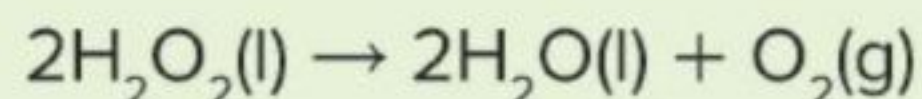
Write the thermochemical equation for the formation of 1 mole of SO₃.

Your Guide to Success

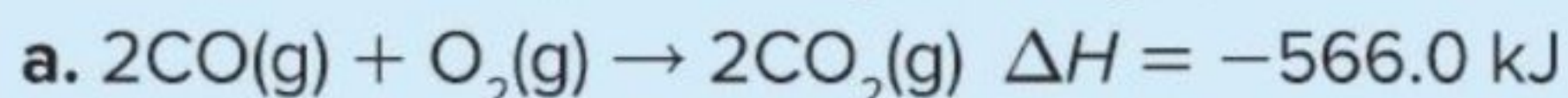


Hess's Law _ Practice problems

HESS'S LAW Use thermochemical Equations **a** and **b** below to determine ΔH for the decomposition of hydrogen peroxide (H_2O_2), a compound that has many uses ranging from bleaching hair to powering rocket engines.



Use Equations **a** and **b** to determine ΔH for the following reaction.

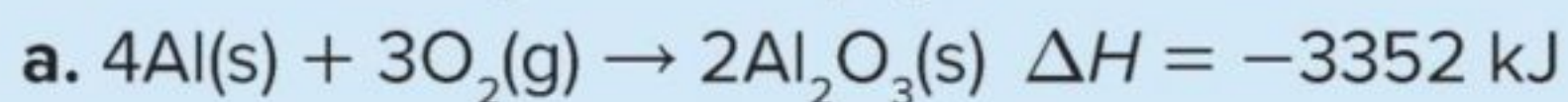
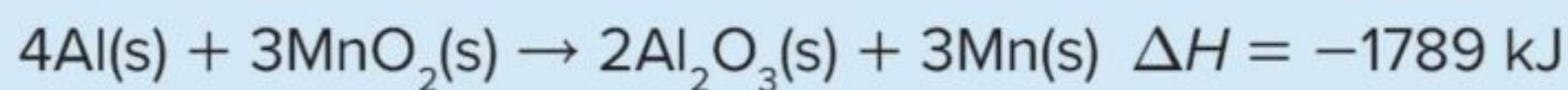


Your Guide to Success

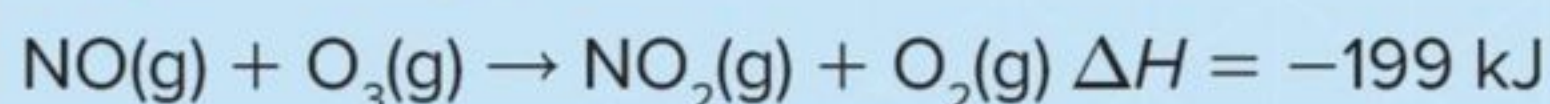
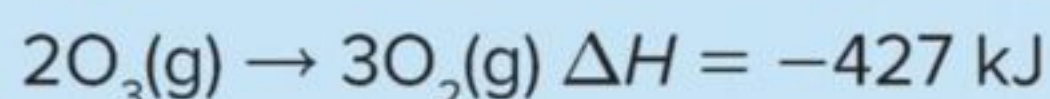
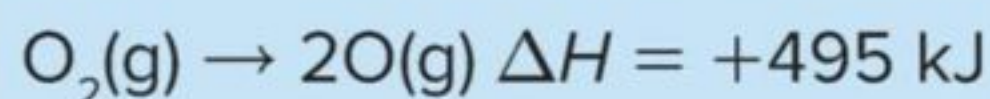




CHALLENGE ΔH for the following reaction is -1789 kJ . Use this and Equation **a** to determine ΔH for Equation **b**.



Calculate Use Hess's law to determine ΔH for the reaction $\text{NO(g)} + \text{O(g)} \rightarrow \text{NO}_2\text{(g)}$ given the following reactions. Show your work.

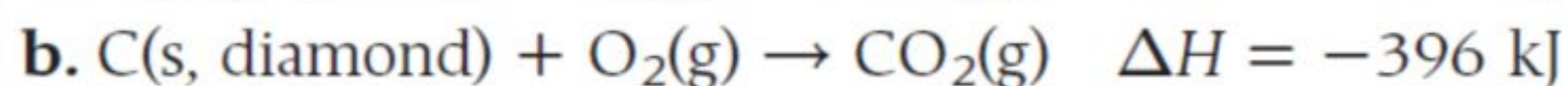
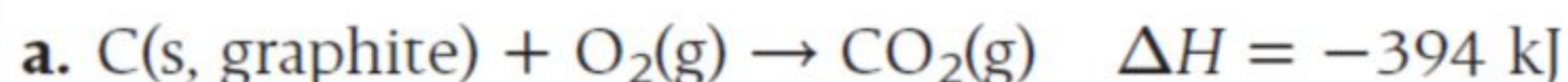


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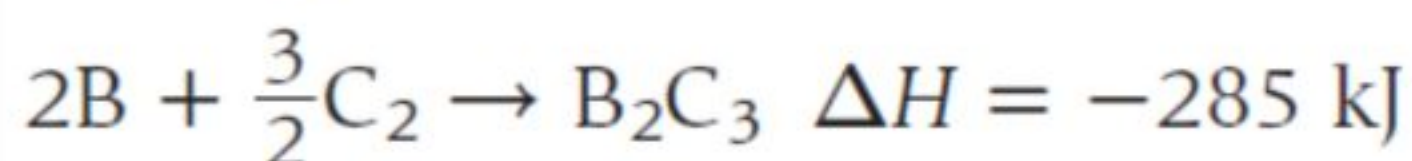
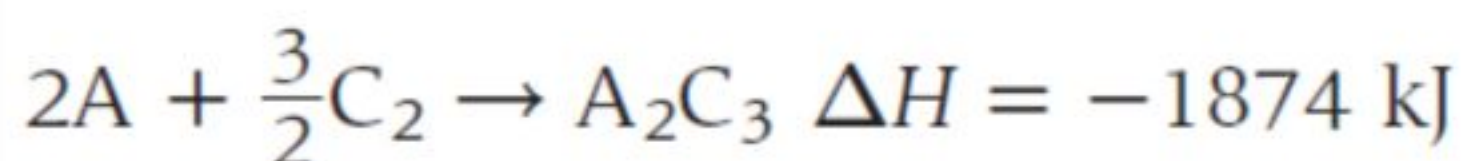




Use Hess's law and the following thermochemical equations to produce the thermochemical equation for the reaction $\text{C(s, diamond)} \rightarrow \text{C(s, graphite)}$. What is ΔH for the reaction?



Use Hess's law and the changes in enthalpy for the following two generic reactions to calculate ΔH for the reaction $2\text{A} + \text{B}_2\text{C}_3 \rightarrow 2\text{B} + \text{A}_2\text{C}_3$.



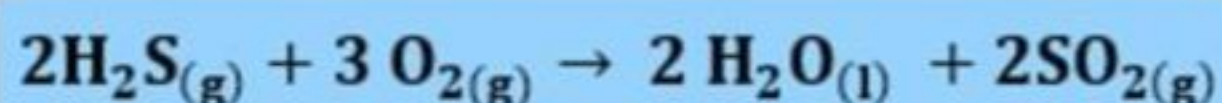
THE GARDEN ACADEMY
Your Guide to Success





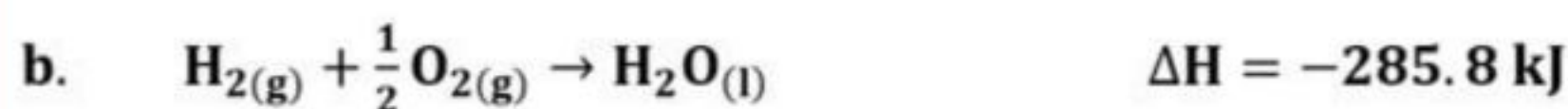
What is the value of ΔH for the following reaction?

ما قيمة ΔH للتفاعل التالي؟



Use thermochemical equations (a,b and c) shown below:

استخدم المعادلات الكيميائية الحرارية (a ، b و c) الموضحة أدناه:



-1124 kJ

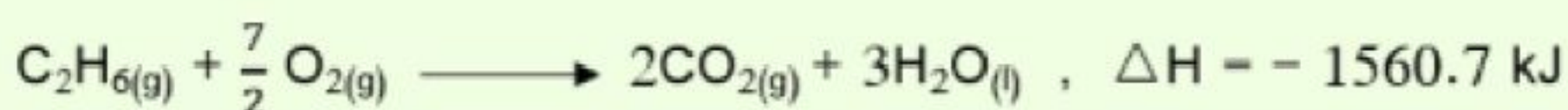
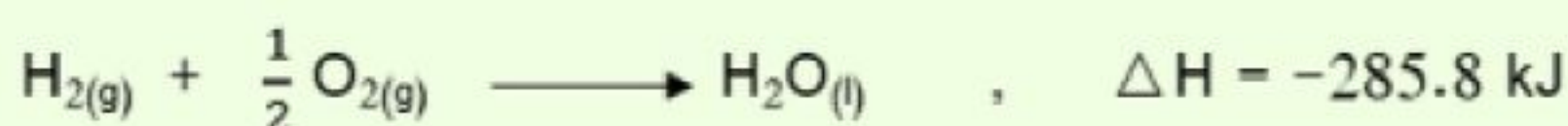
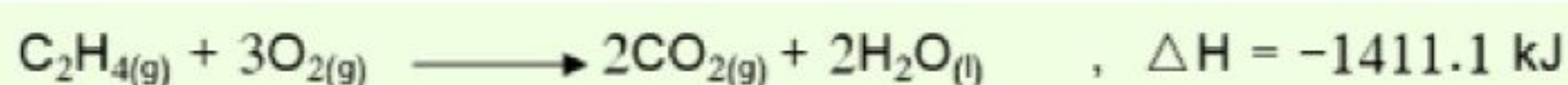
-603.2 kJ

-1206 kJ

-562.0 kJ

Using the following equations:

مُستخدماً المعادلات التالية:



What is the change in enthalpy ΔH of the reaction below, in units (kJ)?

ما مقدار التغير في المحتوى الحراري ΔH للتفاعل أدناه بوحدة (kJ)؟



-136.2

+153.5

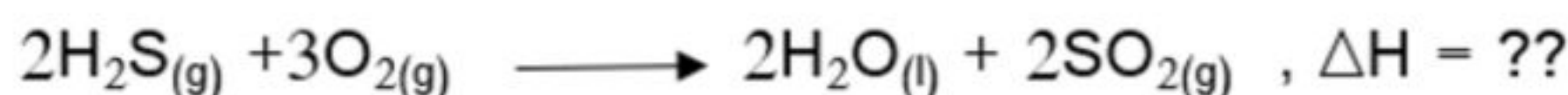
+175.4

-215.3



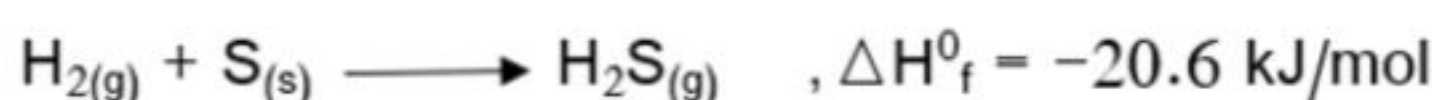
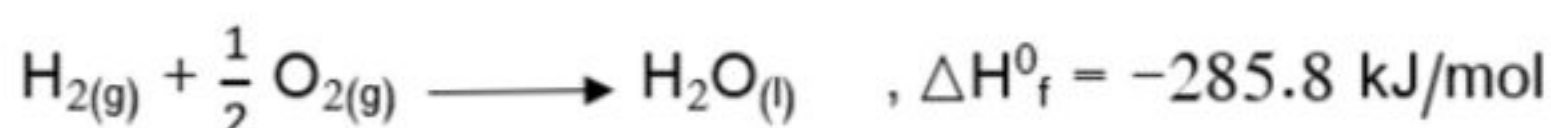
What is the enthalpy change ΔH for the reaction below?

ما مقدار التغير في المحتوى الحراري ΔH للتفاعل أدناه؟



using the following equations:

مُستخدماً المعادلات التالية:



-1206.4 kJ

-562.0 kJ

-603.2 kJ

-1124 kJ

Using thermochemical equations, I, II and III below,

مُستخدماً المعادلات الكيميائية الحرارية I و II و III أدناه ،

What is the ΔH° value for the following reaction?

ما قيمة ΔH° للتفاعل التالي؟



I	$2\text{OF}_{2(g)} \rightarrow \text{O}_{2(g)} + 2\text{F}_{2(g)}$	$\Delta H^\circ = -49.9 \text{ kJ}$
II	$2\text{ClF}_{(g)} + \text{O}_{2(g)} \rightarrow \text{Cl}_2\text{O}_{(g)} + \text{OF}_{2(g)}$	$\Delta H^\circ = +205.6 \text{ kJ}$
III	$\text{ClF}_{3(g)} + \text{O}_{2(g)} \rightarrow \frac{1}{2}\text{Cl}_2\text{O}_{(g)} + \frac{3}{2}\text{OF}_{2(g)}$	$\Delta H^\circ = +266.7 \text{ kJ}$

-188 kJ

+422 kJ

+394 kJ

-139 kJ



The summation equation

Summation Equation

$$\Delta H_{\text{rxn}}^{\circ} = \sum \Delta H_f^{\circ} (\text{products}) - \sum \Delta H_f^{\circ} (\text{reactants})$$

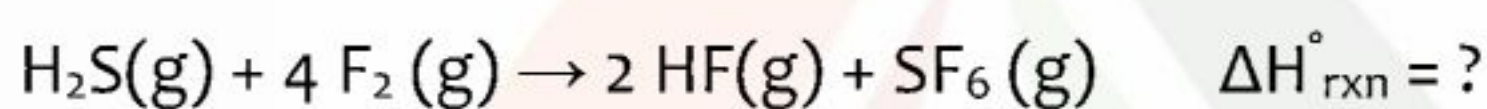
$\Delta H_{\text{rxn}}^{\circ}$ represents the standard enthalpy of the reaction.

Σ represents the sum of the terms.

$\Delta H_f^{\circ} (\text{products})$ and $\Delta H_f^{\circ} (\text{reactants})$ represent the standard enthalpies of formation of all the products and all the reactants.

Note: Always remember that ΔH_f° of any element is zero

Apply this formula to this reaction.



Compound	ΔH_f°
HF	-273
H ₂ S	-21
SF ₆	-1220

Use standard enthalpies of formation to calculate $\Delta H_{\text{rxn}}^{\circ}$ for the combustion of methane.

**Known**

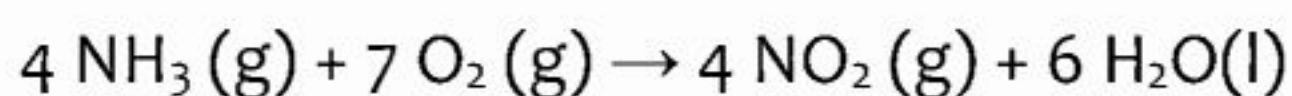
$$\Delta H_f^{\circ} (\text{CO}_2) = -394 \text{ kJ}$$

$$\Delta H_f^{\circ} (\text{H}_2\text{O}) = -286 \text{ kJ}$$

$$\Delta H_f^{\circ} (\text{CH}_4) = -75 \text{ kJ}$$



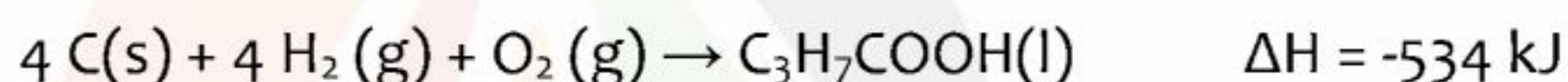
Use standard enthalpies of formation to calculate $\Delta H^\circ_{\text{rxn}}$ for the following reaction.



Compound	ΔH_f°
NH_3	-45.9
NO_2	33.2
H_2O	-286

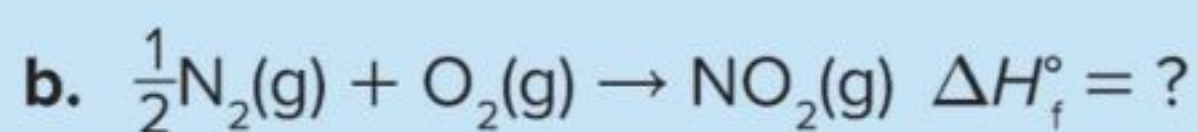
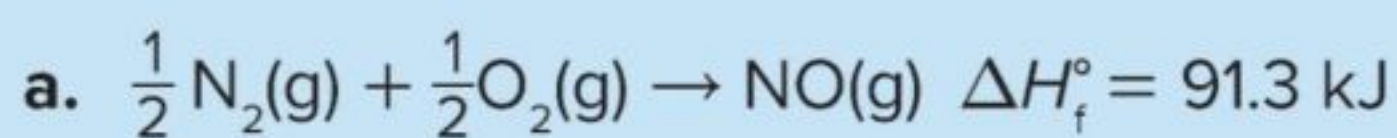
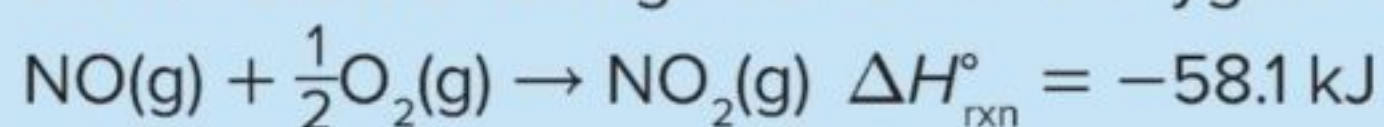
Determine $\Delta H^\circ_{\text{comb}}$ for butanoic acid, $\text{C}_3\text{H}_7\text{COOH}(\text{l}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 4 \text{H}_2\text{O}(\text{l})$.

Use data in the table and the following equation.



Compound	ΔH_f°
CO_2	-394
H_2O	-286

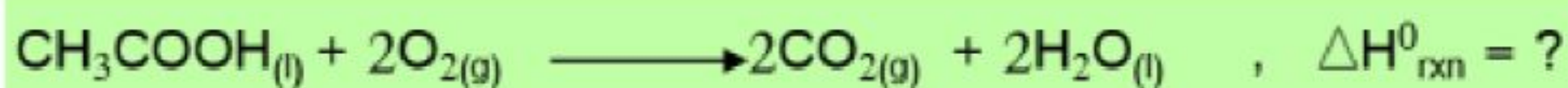
37. CHALLENGE Two enthalpy of formation equations, **a** and **b**, combine to form the equation for the reaction of nitrogen oxide and oxygen. The product of the reaction is nitrogen dioxide:



What is ΔH_f° for Equation **b**?



Using the heat of formation values in the table below, ما مقدار $\Delta H^{\circ}_{\text{rxn}}$ لتفاعل
what is the amount of $\Delta H^{\circ}_{\text{rxn}}$ for the next combustion
الاحتراق التالي؟
reaction?



$\text{CH}_3\text{COOH}_{(l)}$	$\text{H}_2\text{O}_{(l)}$	$\text{CO}_{2(g)}$	المادة Substance
-484.9	-286	-394	حرارة التكوين القياسية ΔH°_f kJ/mol standard enthalpy of formation

+771 kJ/mol

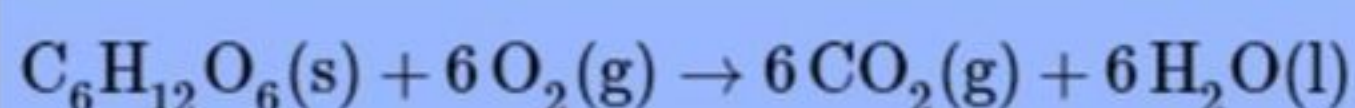
+680 kJ/mol

-875 kJ/mol

-820 kJ/mol

Using the values of standard enthalpies(heat) of formation
below, what is the $\Delta H^{\circ}_{\text{rxn}}$ value for the following reaction?

مُستخدمًا قيم حرارة التكوين القياسية أدناه، ما قيمة $\Delta H^{\circ}_{\text{rxn}}$
للتفاعل التالي؟



$\text{C}_6\text{H}_{12}\text{O}_{6(s)}$	$\text{H}_2\text{O}_{(l)}$	$\text{CO}_{2(g)}$	المادة substance
-1273.3	-285.8	-393.5	$(\text{kJ/mol}) \Delta H^{\circ}_f$

-1901

-2803

-594

-5349



If the enthalpy change of the following reaction
is -1368.4 kJ

إذا كان التغير في المحتوى الحراري للتفاعل التالي

هو -1368.4 kJ



What is the enthalpy of formation of $\text{C}_2\text{H}_5\text{OH}_{(l)}$

فما مقدار حرارة تكوين $\text{C}_2\text{H}_5\text{OH}_{(l)}$

$\text{H}_2\text{O}_{(l)}$	$\text{CO}_{2(g)}$	المادة Substance
-286	-394	حرارة التكوين القياسية ΔH_f° kJ/mol standard enthalpy of formation

$+173.8 \text{ kJ/mol}$

-277.6 kJ/mol

$+142.9 \text{ kJ/mol}$

-102.1 kJ/mol

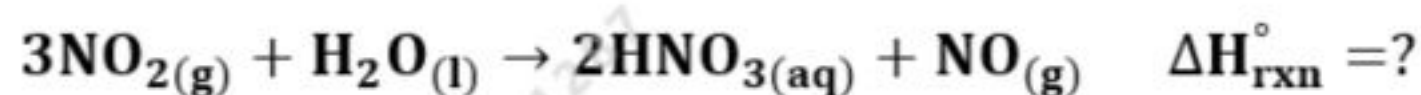
Using standard enthalpies of formation table below

مُستخدمًا جدول قيم حرارة التكوين القياسية أدناه

المادة Substance	ΔH_f° (kJ/mol)
$\text{NO}_{2(g)}$	33.2
$\text{H}_2\text{O}_{(l)}$	-285.8
$\text{HNO}_{3(aq)}$	-207.4
$\text{NO}_{(g)}$	91.3

What is the ΔH_{rxn}° value for the following reaction?

ما قيمة ΔH_{rxn}° للتفاعل التالي؟



$+136 \text{ kJ}$

-137 kJ

$+368 \text{ kJ}$

-506 kJ

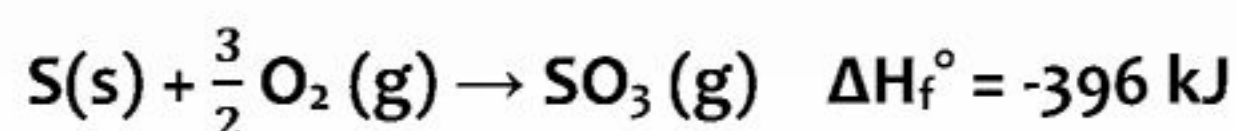




Standard Enthalpy (Heat) of Formation

The **standard enthalpy (heat) of formation** (ΔH_f°) is defined as the change in enthalpy that accompanies the formation of **one mole of the compound** in **its standard state** from its **elements in their standard states**.

Example:



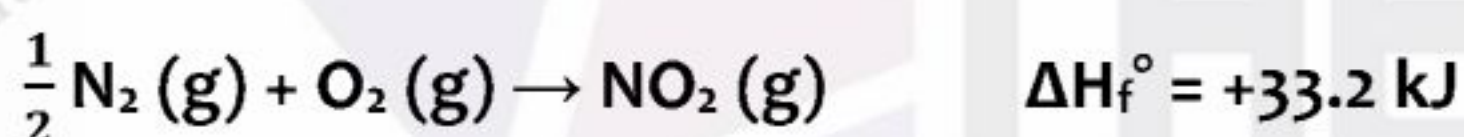
The **standard state** of a substance means the normal physical state at 1 atm and 298 K (25°C).

The standard state of iron is, for mercury is, for oxygen is

Where do standard heats of formation come from?

Elements in their standard state have a ΔH_f° of 0.0 kJ. The experimentally determined enthalpies of formation of compounds can be placed on a scale above and below the elements in their standard states.

Enthalpies of formation from experiments



The standard enthalpies of formation for nitrogen and oxygen are

This reaction is as it energy.

The energy content of the product NO_2 is than the energy content of the reactants N_2 and O_2 .

Write the equation for the formation of sulfur trioxide (SO_3).

This reaction is as it energy.

The energy content of the product SO_3 is than the energy content of the reactants.

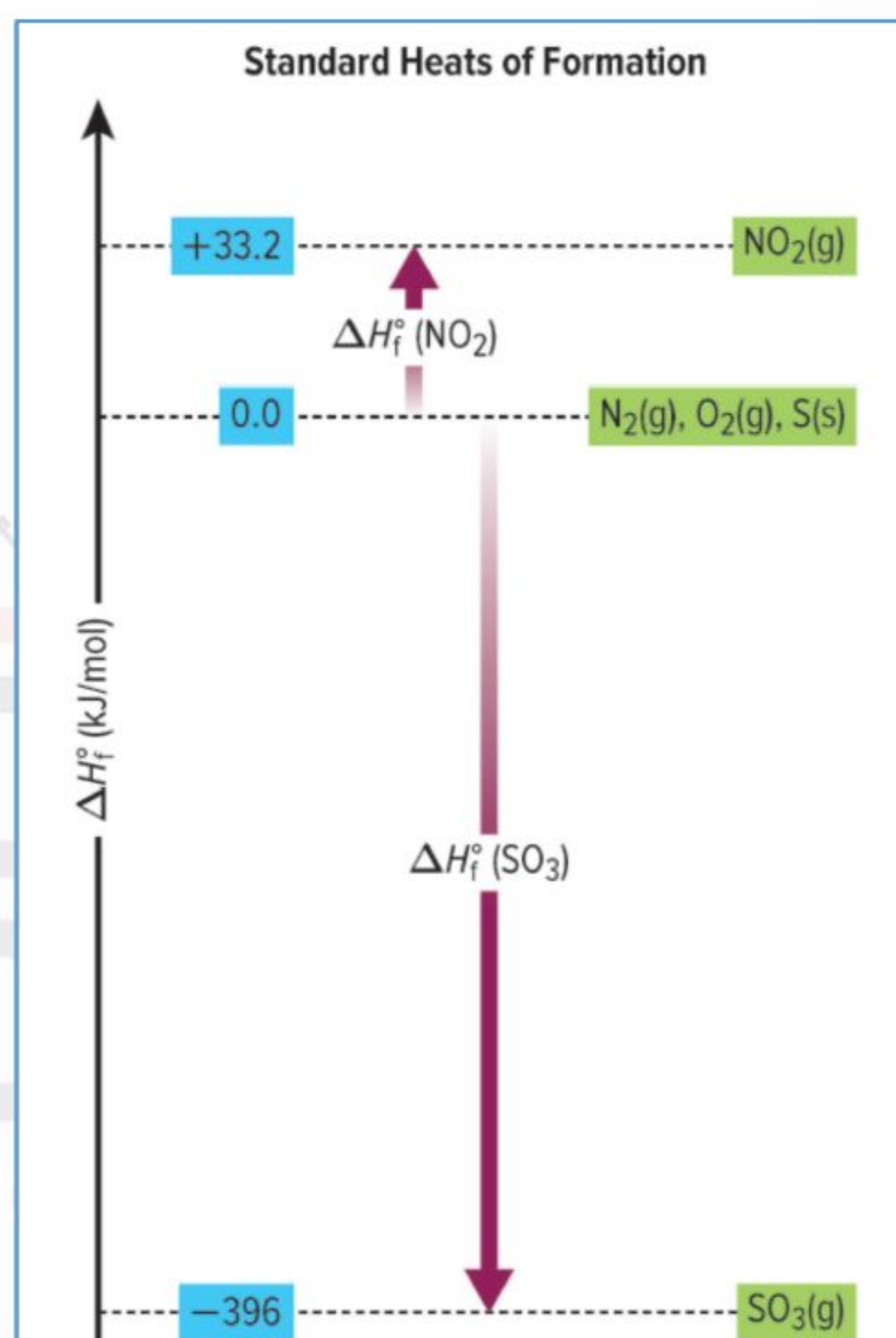


Figure 15 ΔH_f° for the elements N_2 , O_2 , and S is 0.0 kJ. When N_2 and O_2 react to form 1 mole of NO_2 , 33.2 kJ is absorbed. Thus, ΔH_f° for NO_2 is +33.2 kJ/mol. When S and O_2 react to form one mole of SO_3 , 396 kJ is released. Therefore, ΔH_f° for SO_3 is -396 kJ/mol.

Predict the approximate location of water on the scale. The heat of formation for the reaction $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ is $\Delta H_f^\circ = -286 \text{ kJ/mol}$.

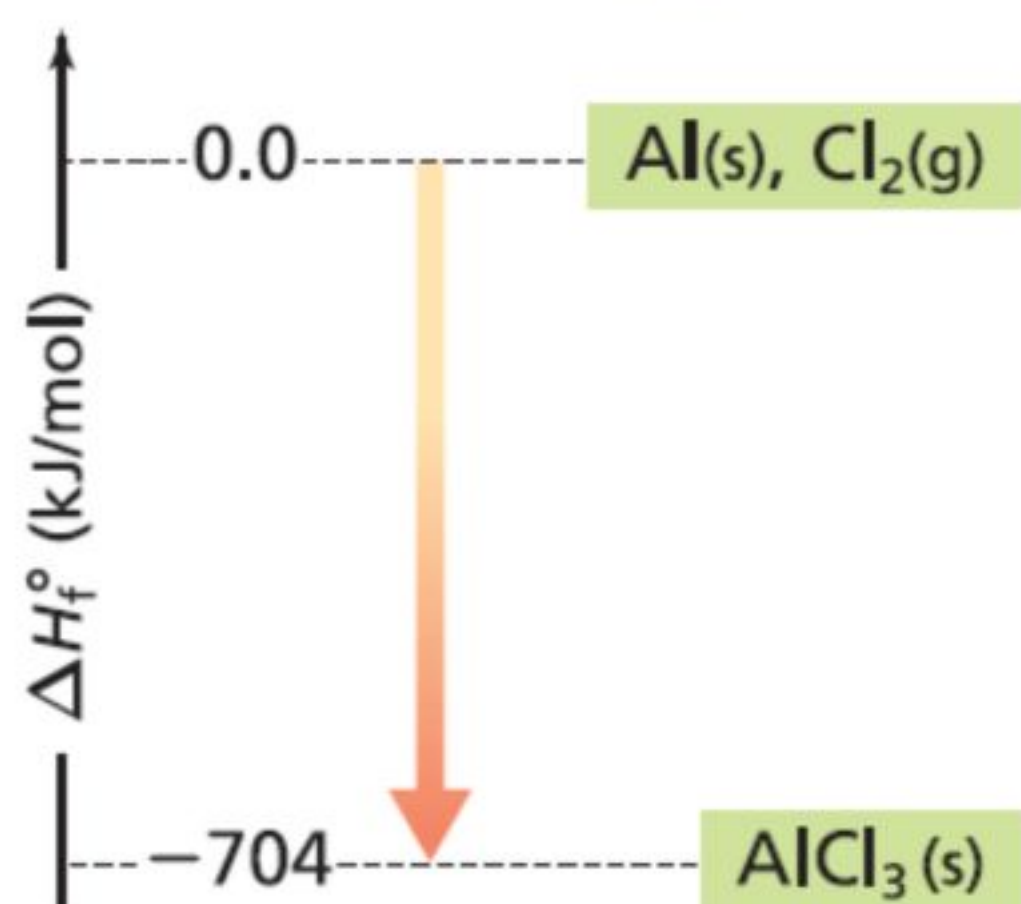


Practice_Heat of Formation

Interpret Scientific Illustrations Use the data below to draw a diagram of standard heats of formation similar to **Figure 15**, and use your diagram to determine the heat of vaporization of water at 298 K.

Liquid water: $\Delta H_f^\circ = -285.8 \text{ kJ/mol}$

Gaseous water: $\Delta H_f^\circ = -241.8 \text{ kJ/mol}$

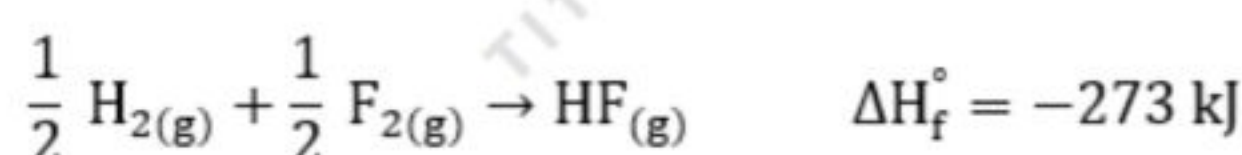
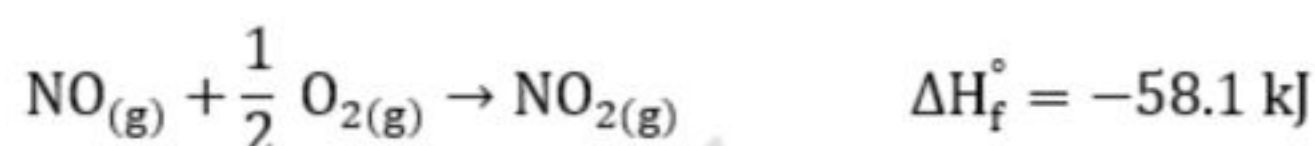
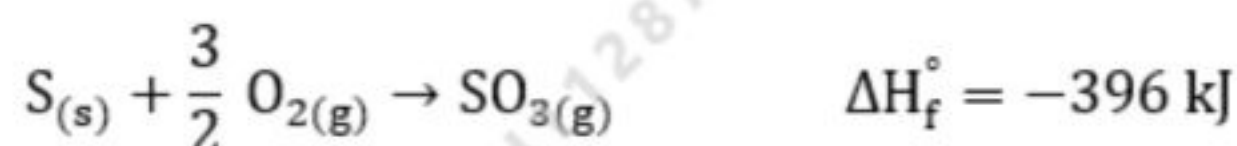


■ Figure 25

Use **Figure 25** to write the thermochemical equation for the formation of 1 mol of aluminum chloride (a solid in its standard state) from its constituent elements in their standard states.

Which of the enthalpy changes in the following reactions **does not** represent a standard heat of formation ΔH_f° ?

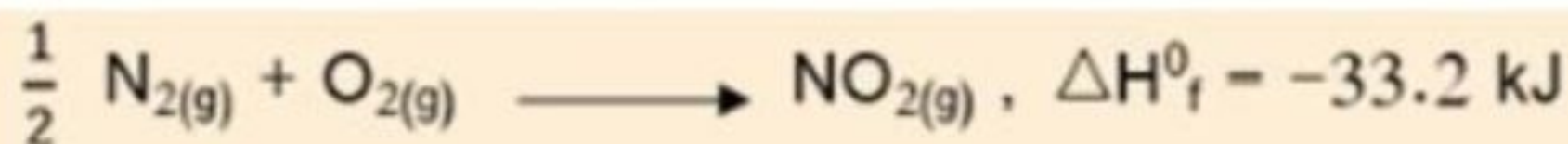
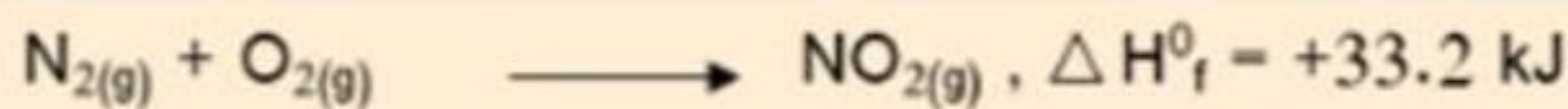
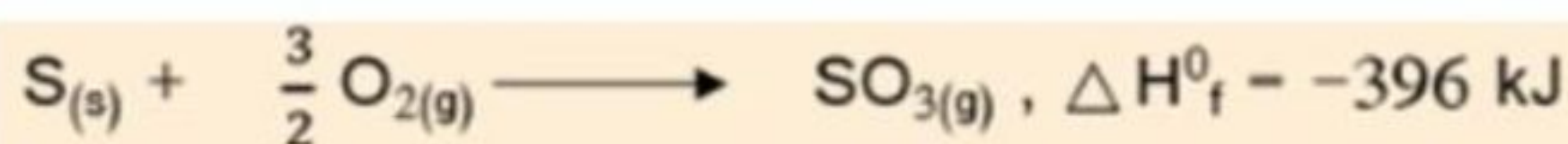
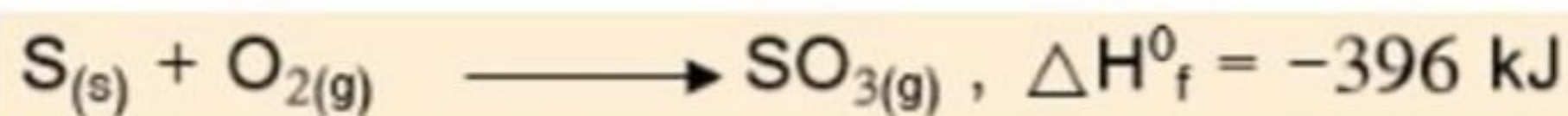
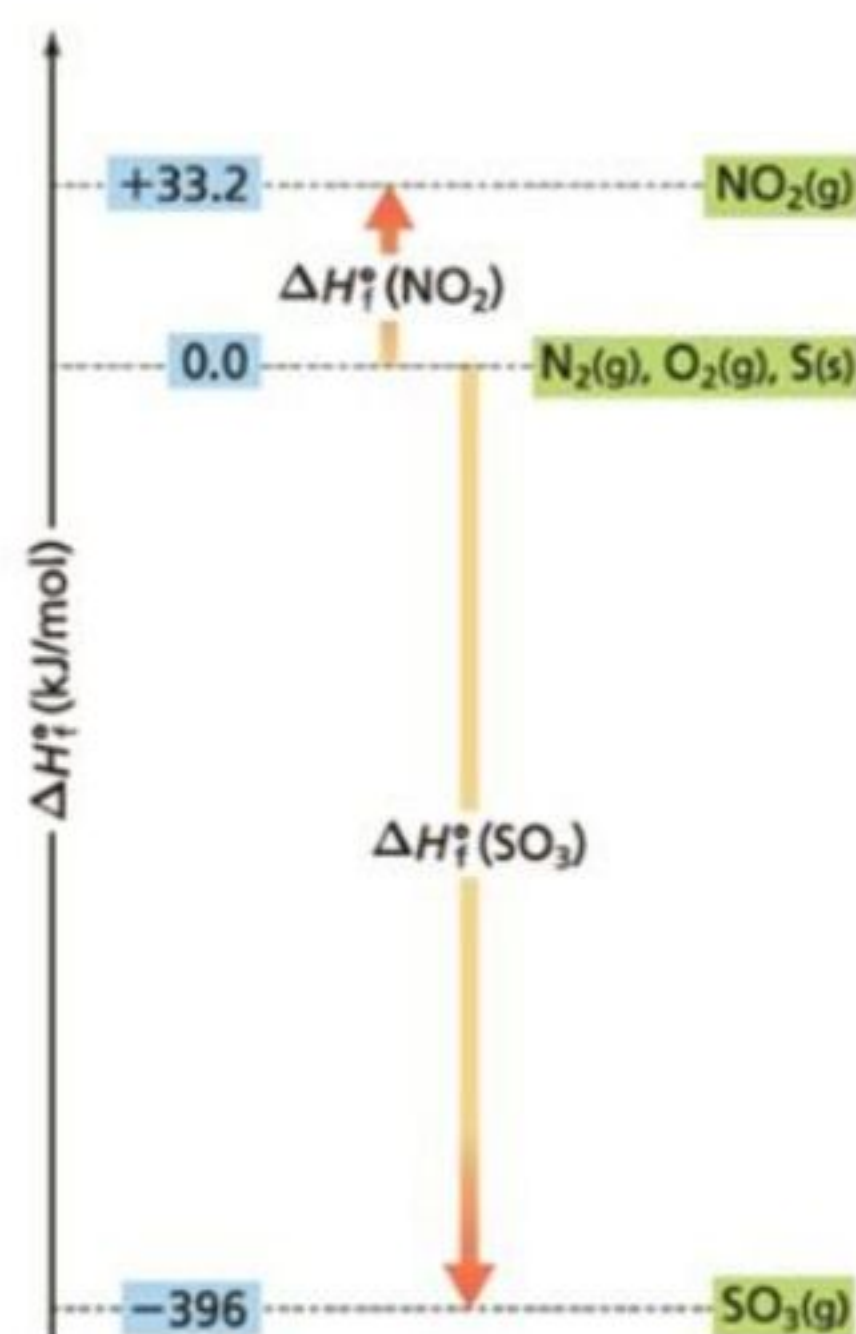
أي من التغيرات في المحتوى الحراري في التفاعلات التالية **لا** يمثل حرارة تكوين قياسية ΔH_f° ؟





Which of the following thermochemical equations is correct based on the figure below?

أي المعادلات الحرارية التالية صحيحة بناءً على الشكل أدناه؟



Tarek Mohamed

Tarek Mohamed

Tarek Mohamed

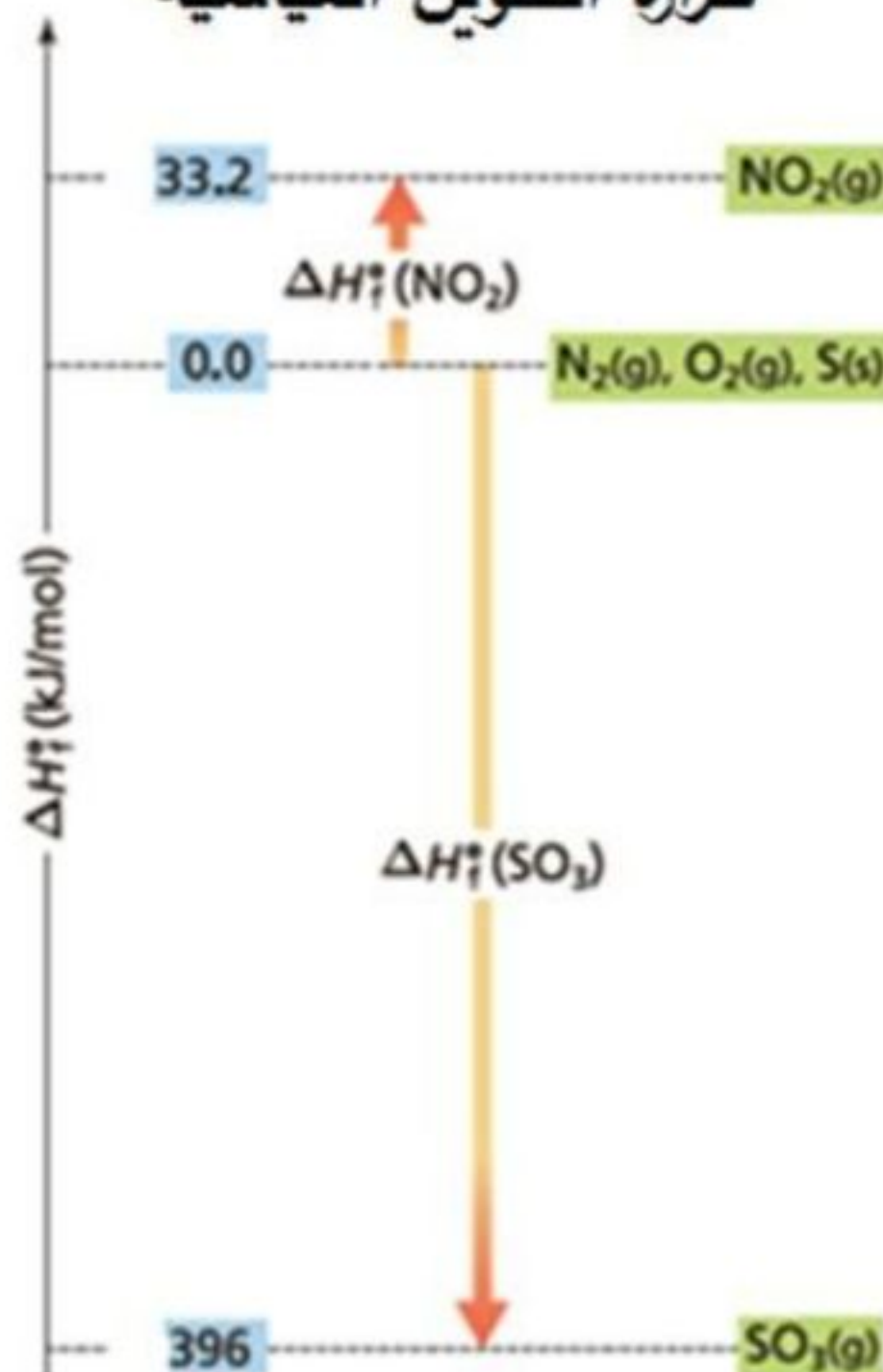
Tarek Mohamed



فيما يتعلق بالمركبات في الشكل أدناه، أي المعادلات التالية **صحيحة**؟
Regarding the compounds in the figure below, which of the following equations is **correct**?

Standard Heats of Formation

حرارة التكوين القياسية



1	$\frac{1}{2} \text{N}_{2(g)} + \text{O}_{2(g)} + 33.2 \text{ kJ} \longrightarrow \text{NO}_{2(g)}$
2	$\text{S}_{(s)} + \frac{3}{2} \text{O}_{2(g)} + 396 \text{ kJ} \longrightarrow \text{SO}_{3(g)}$
3	$\text{S}_{(s)} + \frac{3}{2} \text{O}_{2(g)} \longrightarrow \text{SO}_{3(g)}, \Delta H^\circ = -396 \text{ kJ}$
4	$\frac{1}{2} \text{N}_{2(g)} + \text{O}_{2(g)} \longrightarrow \text{NO}_{2(g)}, \Delta H^\circ = -33.2 \text{ kJ}$

1 only

1 فقط

2 only

2 فقط

1 and 3

1 و 3

3 and 4

3 و 4



Which of the ΔH values given in the following reactions represents **the standard enthalpy of formation** ΔH_f° of NO_2 compound?

أي من قيم ΔH المُعطاة في التفاعلات التالية تُمثل حرارة التكوين القياسية ΔH_f° للمركب NO_2 ؟

1	$\text{NO}_{(g)} + \text{O}_{3(g)} \rightarrow \text{NO}_{2(g)} + \text{O}_{2(g)}$	$\Delta H = -199 \text{ kJ}$
2	$\frac{1}{2} \text{N}_{2(g)} + \text{O}_{2(g)} \rightarrow \text{NO}_{2(g)}$	$\Delta H = +33.2 \text{ kJ}$
3	$\text{N}_{2(g)} + 2\text{O}_{2(g)} \rightarrow 2\text{NO}_{2(g)}$	$\Delta H = +66.4 \text{ kJ}$
4	$\text{NO}_{(g)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{NO}_{2(g)}$	$\Delta H = -58.1 \text{ kJ}$

$$\Delta H = -199 \text{ kJ}$$

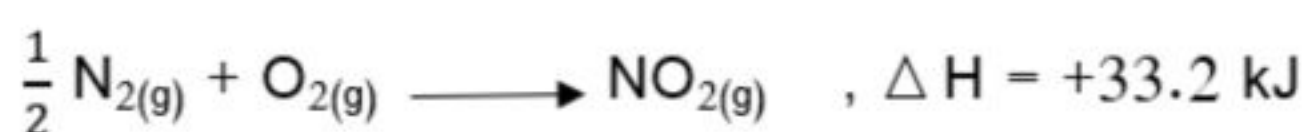
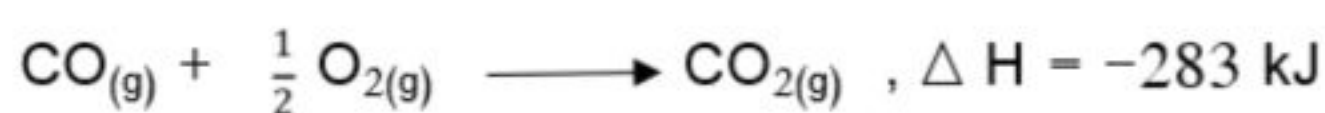
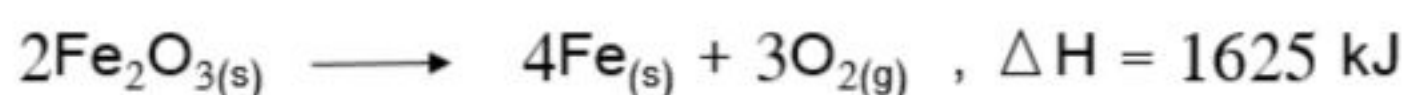
$$\Delta H = +33.2 \text{ kJ}$$

$$\Delta H = -58.1 \text{ kJ}$$

$$\Delta H = +66.4 \text{ kJ}$$

Which of the enthalpy changes in the following reactions represents a standard heat of formation (ΔH_f°) ?

أي من التغيرات في المحتوى الحراري في التفاعلات التالية يُمثل حرارة تكوين قياسية (ΔH_f°) ؟





Which of the following **represents** the standard enthalpy of formation for the compound formed in the following reaction?

أي مما يلي **يمثل** حرارة تكوين قياسية للمركب الناتج من التفاعلات التالية؟



Which of the enthalpy changes in the following reactions أي من التغيرات في المحتوى الحراري في التفاعلات التالية يُمثل حرارة احتراق قياسية وحرارة تكوين قياسية معاً؟
represents **both** standard heat of combustion and standard heat of formation?

1	$2\text{SO}_{2(g)} + \text{O}_{2(g)} \longrightarrow 2\text{SO}_{3(g)}$, $\Delta H = -792 \text{ kJ}$
2	$2\text{CO}_{(g)} + 2\text{NO}_{(g)} \longrightarrow 2\text{CO}_{2(g)} + \text{N}_{2(g)}$, $\Delta H = -385.4 \text{ kJ}$
3	$\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(l)}$, $\Delta H = -286 \text{ kJ}$
4	$\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(g)}$, $\Delta H = -242 \text{ kJ}$

Your Guide to Success



Expressing Reaction Rates

The average rate of an action or process is defined as the change in a given quantity during a specific period of time.

$$\text{average rate} = \frac{\Delta \text{quantity}}{\Delta t}$$

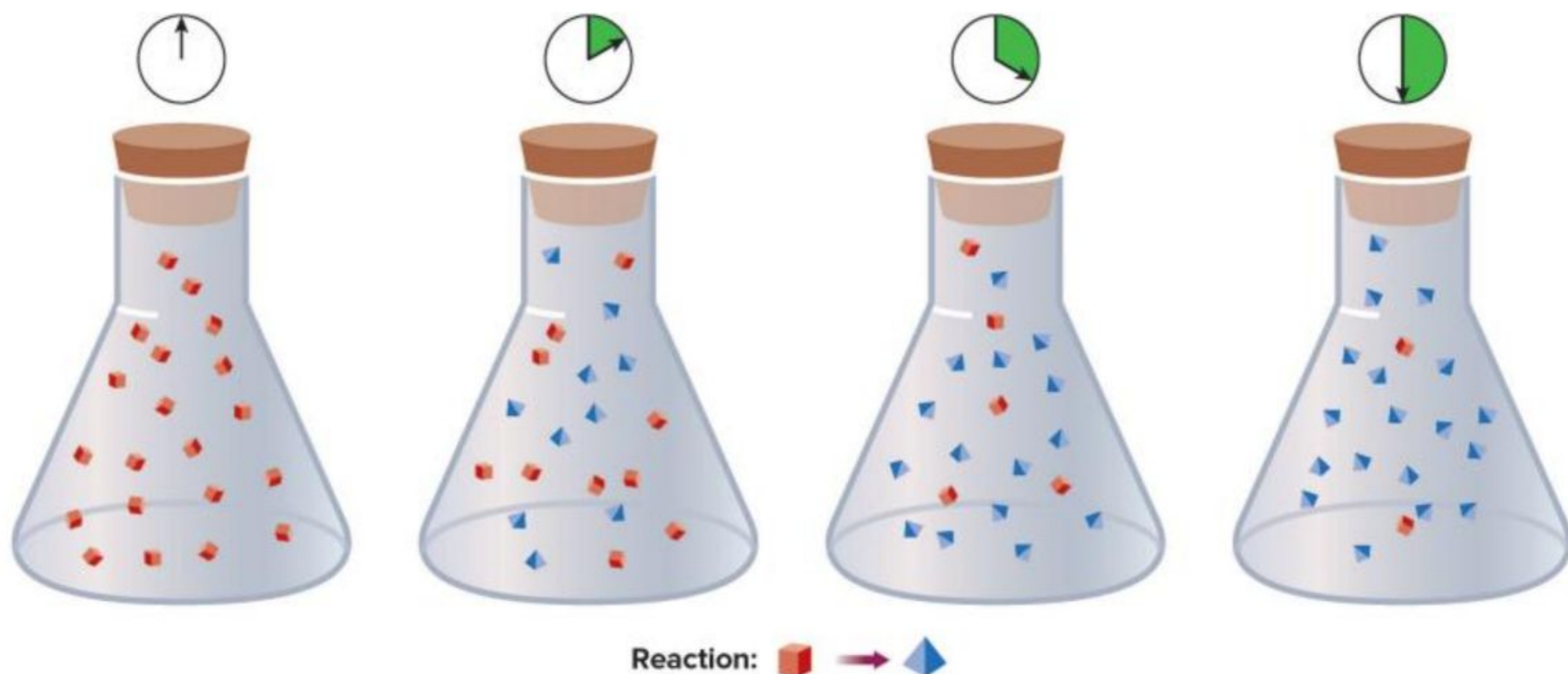


Figure 2 Over time, the reactant changes to a product. The rate of a chemical reaction can be expressed as a change in the number of moles of a reactant or product during an interval of time.

Notice that the amount of the reactant as the amount of product

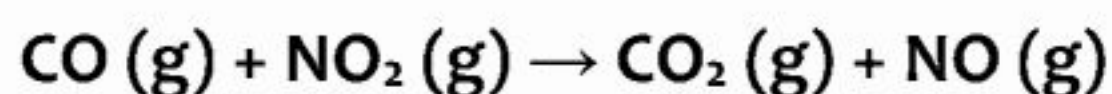
The **reaction rate** of a chemical reaction is generally stated as the change in concentration of a reactant or product per unit of time, expressed as mol/ (L · s).

Brackets around the formula [NO] represents the..... of NO.

Example

If the initial concentration of NO is 0.000M and 0.010M two seconds after the reaction begins.

Calculate the average rate of NO in this reaction.





When the rate is measured by the consumption of a reactant, the value will be negative. Why?

.....

Average Reaction Rate Equation

$$\text{Average reaction rate} = -\frac{\Delta[\text{reactant}]}{\Delta t}$$

$\Delta[\text{reactant}]$ represents the change in concentration of a reactant.

Δt represents the change in time.

Example

In a reaction between butyl chloride ($\text{C}_4\text{H}_9\text{Cl}$) and water, the concentration of $\text{C}_4\text{H}_9\text{Cl}$ is 0.220M at the beginning of the reaction. At 4.00 s, the concentration of $\text{C}_4\text{H}_9\text{Cl}$ is 0.100M. Find the average reaction rate.

Use the data in the following table to calculate the average reaction rates.

Time (s)	$[\text{H}_2]$ (M)	$[\text{Cl}_2]$ (M)	$[\text{HCl}]$ (M)
0.00	0.030	0.050	0.000
4.00	0.020	0.040	

1. Calculate the average reaction rate expressed in moles H_2 consumed per liter per second.
2. Calculate the average reaction rate expressed in moles Cl_2 consumed per liter per second.
3. If the average reaction rate for the reaction, expressed in moles of HCl formed, is 0.0050 mol/(L.s), what concentration of HCl would be present after 4.00 s?



Average Rate_Practice

Calculate the average rate of a reaction between hypothetical molecules A and B if the concentration of A changes from $1.00M$ to $0.50M$ in 2.00 s .

How would you express the rate of the chemical reaction $A \rightarrow B$ based on the concentration of Reactant A? How would that rate compare with the reaction rate based on the Product B?

In the gas-phase reaction, $I_2 + Cl_2 \rightarrow 2ICl$, $[I_2]$ changes from $0.400M$ at 0.00 min to $0.300M$ at 4.00 min . Calculate the average reaction rate in moles of I_2 consumed per liter per minute.

In a reaction $Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$, 6.00 g of Mg was present at 0.00 min . After 3.00 min , 4.50 g of Mg remained. Express the average rate as $\text{mol Mg consumed/min}$.

If a chemical reaction occurs at the rate of 2.25×10^{-2} moles per liter per second at 322 K , what is the rate expressed in moles per liter per minute?



Using the experimental data in the following table,
if the average reaction rate for the reaction, expressed in
moles of NO formed, is 0.050 mol/L.s , what concentration of
NO would be present after 0.100 s?

مُستخدماً البيانات التجريبية في الجدول التالي، إذا كان متوسط سرعة التفاعل مُعبّرًا
عنه بعدد مولات NO الناتجة يساوي 0.05 mol/L.s
ما تركيز NO بعد 0.100 s؟

$N_2(g) + O_2(g) \rightarrow 2NO(g)$			
[NO] (M)	[O ₂] (M)	[N ₂] (M)	Time (s) الزمن
0.000	0.300	0.500	0.00
	0.250	0.450	0.100



In the gas – phase reaction $I_2 + Cl_2 \longrightarrow 2ICl$

[I₂] changes from 0.400 M at 0.00 s
to 0.300 M at 4.00 s.

What is the average reaction rate over
the given time period expressed in mol/L.s?

في التفاعل الغازي $I_2 + Cl_2 \longrightarrow 2ICl$

يتغير تركيز اليود I₂ من 0.400 M عند 0.00 s
إلى 0.300 M في 4.00 s .

ما متوسط سرعة التفاعل خلال الفترة الزمنية المعلومة بوحدة mol/L.s؟

0.0250

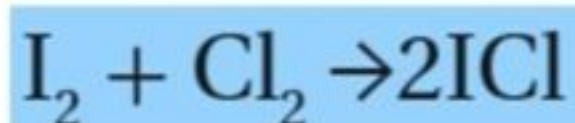
0.0350

0.870

0.690

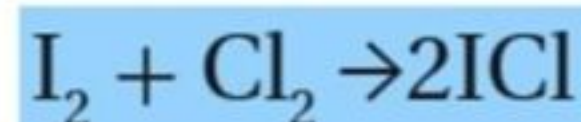


In the gas-phase reaction :



$[\text{I}_2]$ changes from 0.400M at 0.00 min to 0.3840 M at 4.00 min.

What is the average reaction rate in moles of I_2 consumed per liter per minute?



في التفاعل الغازي :

يتغير $[\text{I}_2]$ من 0.400 M عند 0.00 min إلى 0.3840 M في 4.00 min

ما متوسط سرعة التفاعل بمولات I_2 المستهلكة بالتر لكل دقيقة؟

+0.004 mol/(L.min)

– 0.004 mol/(L.min)

+0.01 mol/(L.min)

– 0.01 mol/(L.min)

What is the average rate of a reaction between hypothetical molecules X and Y if the concentration of X changes from 1.00 M to 0.05 M in 2.00 s?

A. 0.233 M/s

B. 0.475 M/s

C. 0.125 M/s

D. 0.95 M/s

ما متوسط سرعة التفاعل بين الجزيئات الافتراضية X و Y إذا كان تركيز X يتغير من 1.00 M إلى 0.05 M في 2.00 s؟

A. 0.233 M/s

B. 0.475 M/s

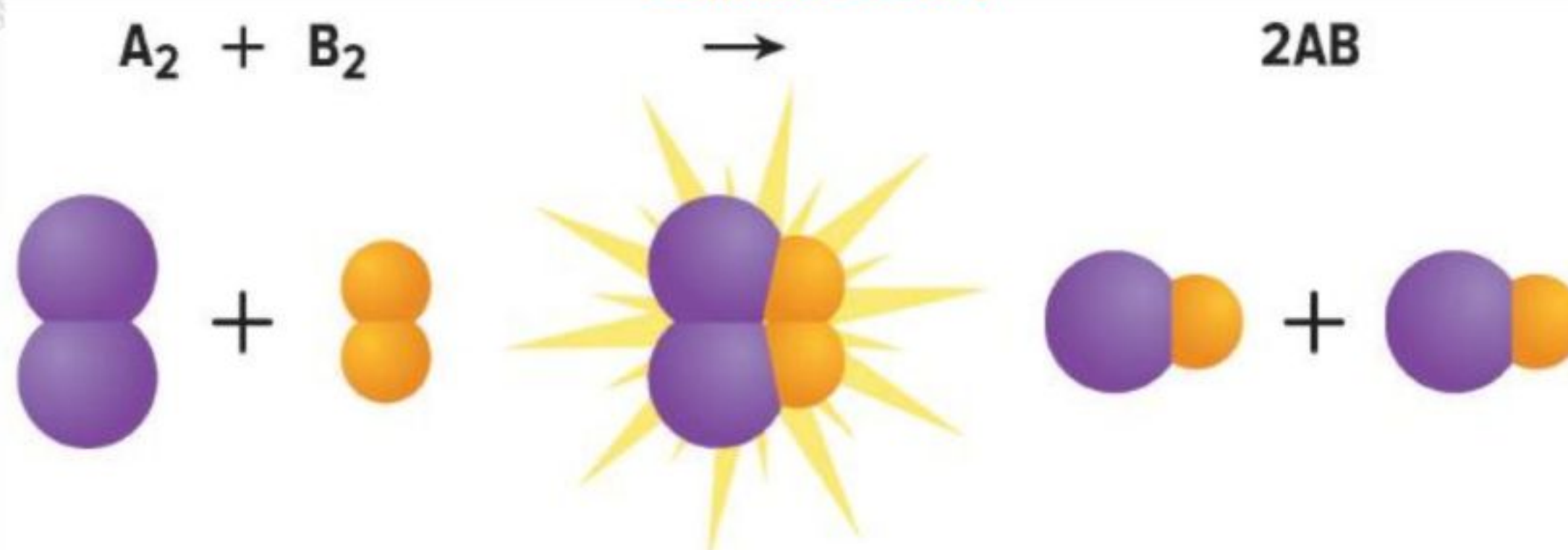
C. 0.125 M/s

D. 0.95 M/s



17	CHM.5.4.01.002.03 List the two conditions, according to the collision theory, that must be met for a collision between reactant molecules to be effective in producing new chemical species	Textbook + figures 3 , 4	49 , 50
18	CHM.5.4.01.022.03 Describe the relationship between activation energy and rate of the reaction	Textbook + figure 5, 6	52

Collision Theory



Collision theory states that atoms, ions, and molecules must collide in order to react.

Predict why a collision between two particles is necessary for a reaction to occur.

.....

.....

Collision Orientation and the Activated Complex

Consider this reaction

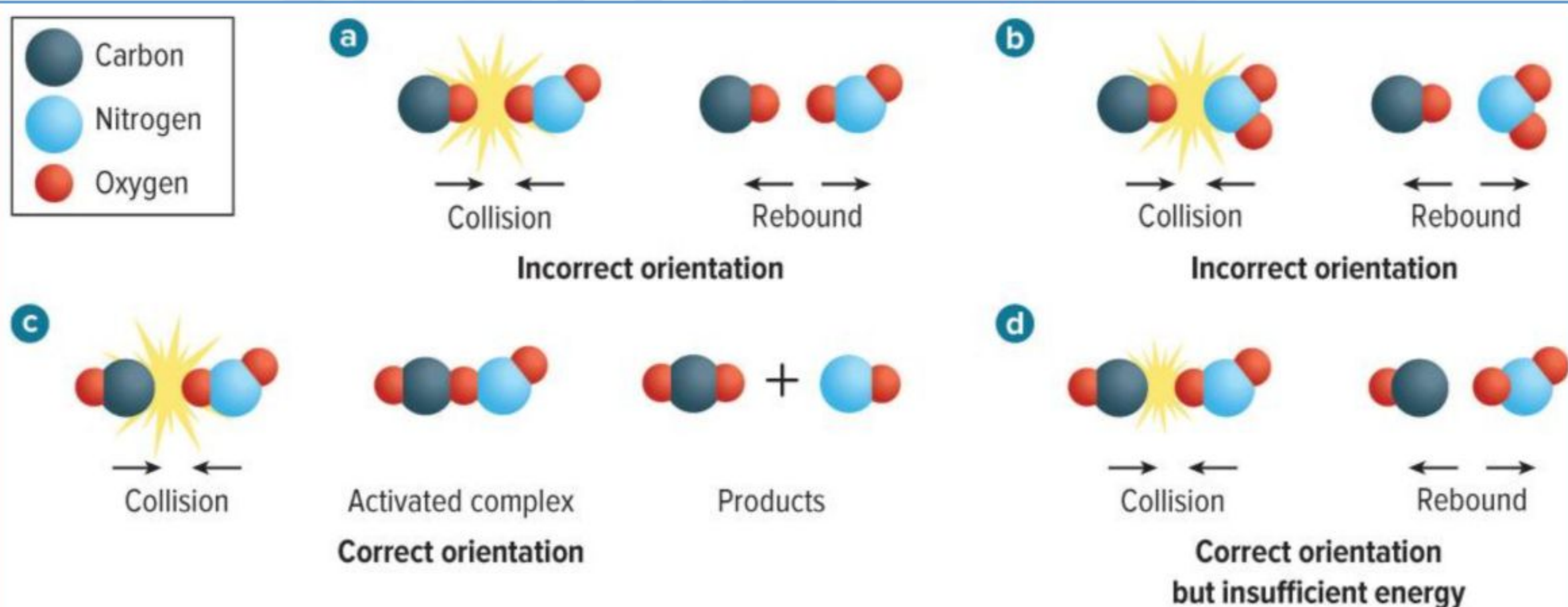
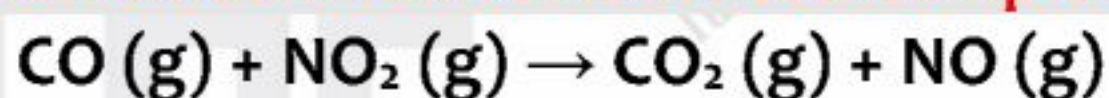


Figure 4 This figure shows four different collision orientations between CO molecules and NO₂ molecules. The collisions in **a** and **b** do not result in a reaction because the molecules are not in position to form bonds. The molecules in **c** collide in the correct orientation, and a reaction occurs. Although the molecules in **d** are also in the correct orientation, they have insufficient energy to react. It is a combination of collision orientation and the energy of the collision that determines if a collision will result in a reaction occurring.

In this reaction, the carbon atom in a CO molecule must contact an oxygen atom in an NO₂ molecule. A temporary bond can form between carbon and oxygen.



What are the conditions for a reaction to occur?

- 1-
- 2-

An **activated complex** (**transition state**), is a **temporary unstable** arrangement of atoms in which old bonds are breaking and new bonds are forming. It might form products or might break apart to re-form the reactants.

What is the formula of the activated complex in the previous reaction?

Activation energy and reaction rate

The minimum amount of energy that reacting particles must have to form the activated complex and lead to a reaction is called the **activation energy** (E_a).

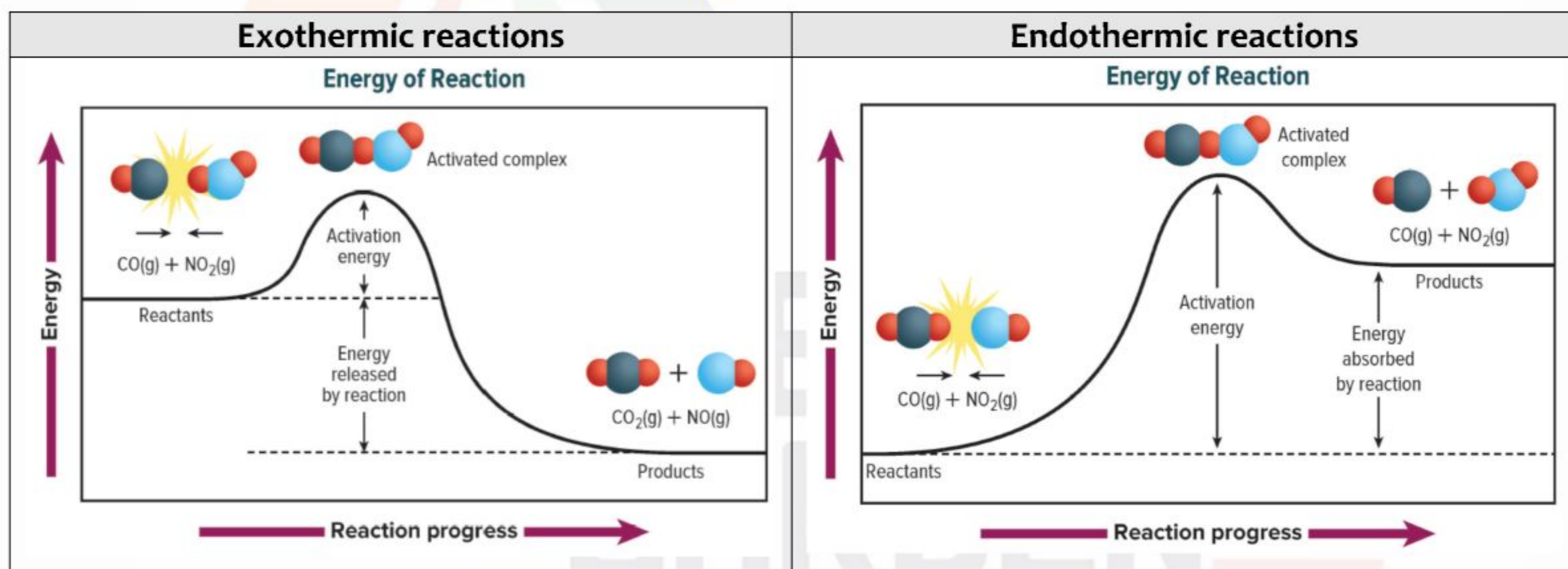


Figure 5 When an exothermic reaction occurs, molecules collide with enough energy to overcome the activation energy barrier. They form an activated complex, then release energy and form products at a lower energy level.

Figure 6 In a reverse reaction, which is endothermic, the reactant molecules are at a lower energy than the products. To react, the reactants must absorb enough energy to overcome the activation energy barrier and form higher-energy products.

This reaction has activation energy.
 amount of energy is required.
 More collisions have the required energy
 The reaction rate is

This reaction has activation energy.
 amount of energy is required.
 Few collisions have the required energy
 The reaction rate is

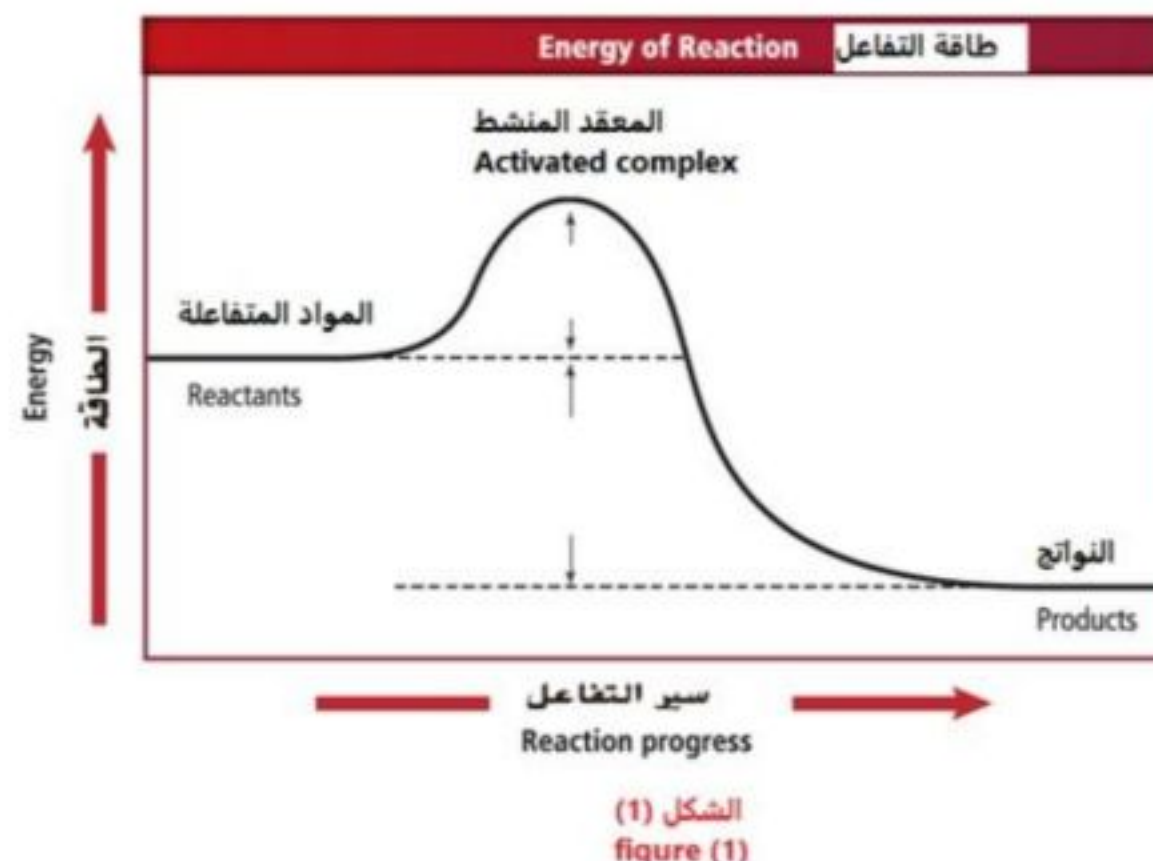
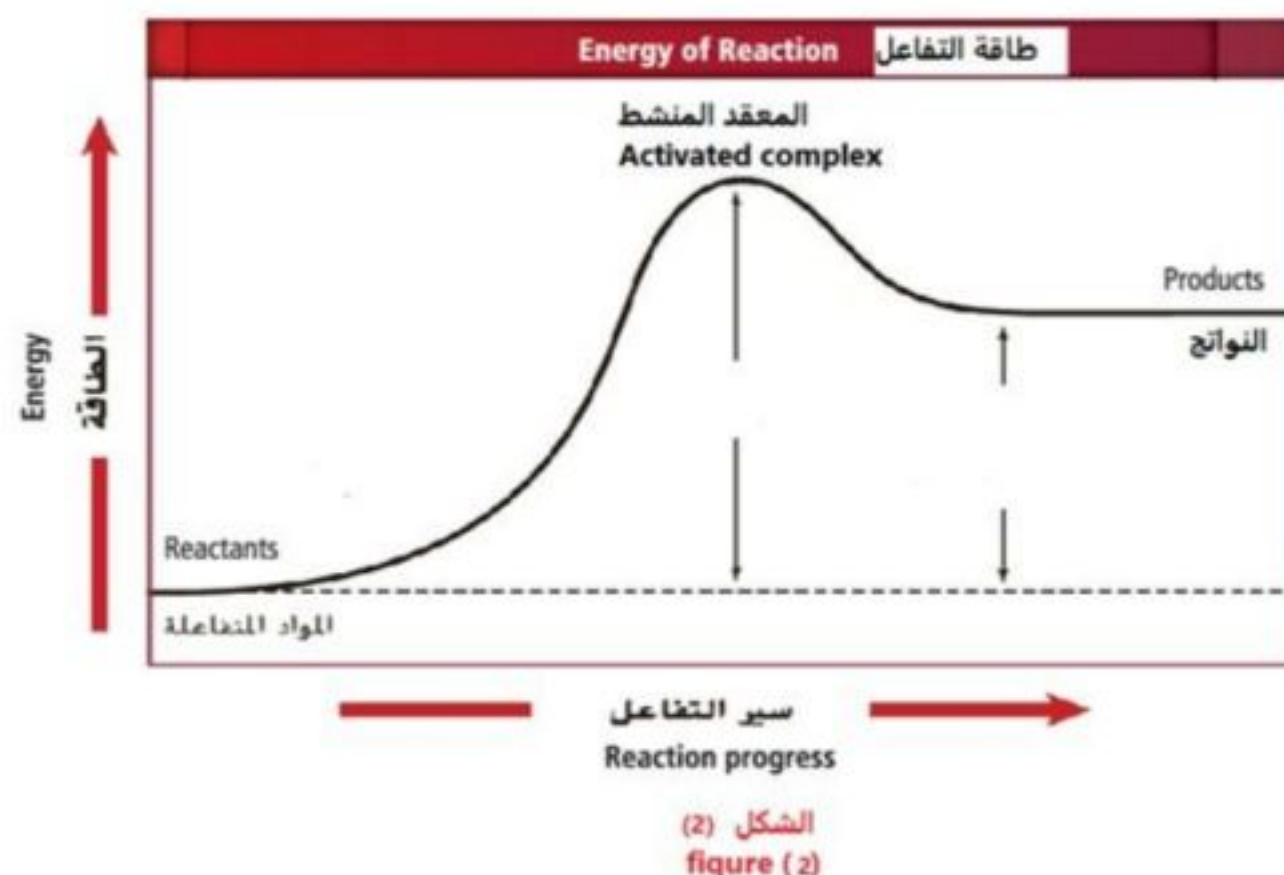
Compare Figures 5 and 6 to determine whether the activation energy for the forward reaction is larger or smaller than the activation energy for the reverse reaction.



Practice_Collision Theory

Using the two figures below, which of the following is **correct**?

مُستخدماً الشكلين أدناه، أي مما يلي **صحيح**؟



Energy is released in figure (1) while energy is absorbed in figure (2)

تنطلق طاقة في الشكل (1) بينما تُمتص طاقة في الشكل (2)

Energy is released in figure (2) while energy is absorbed in figure (1)

تنطلق طاقة في الشكل (2) بينما تُمتص طاقة في الشكل (1)

The activation energy in figure (1) is greater than the activation energy in figure (2)

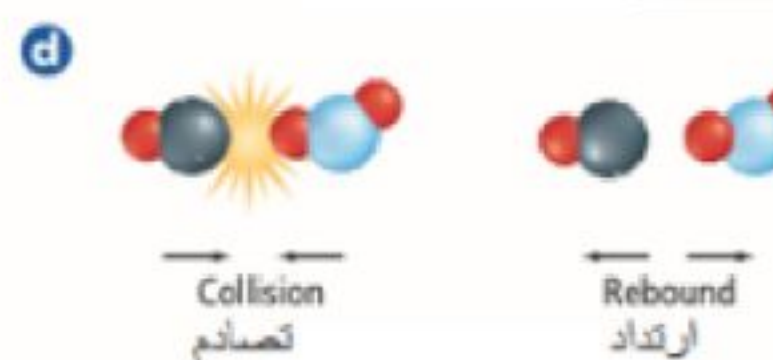
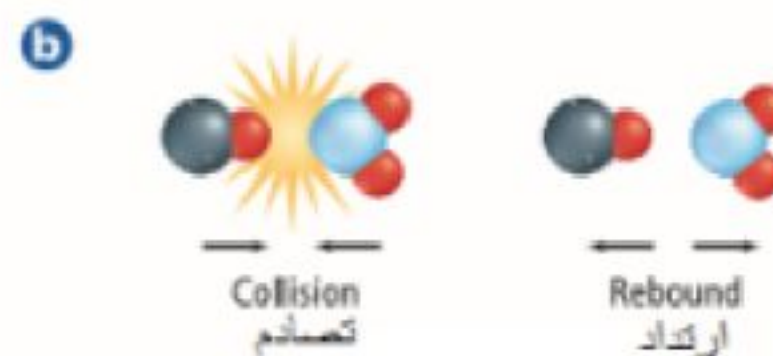
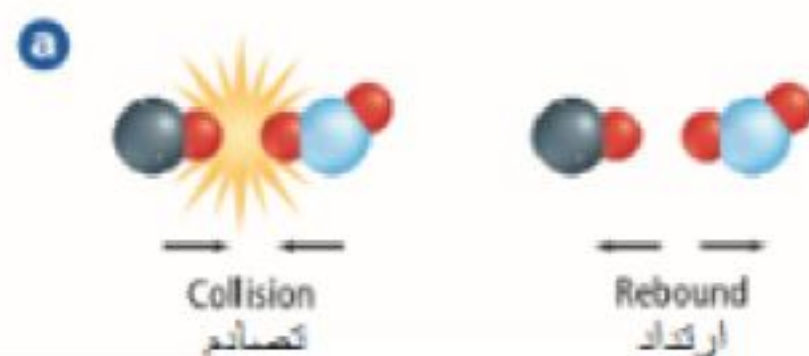
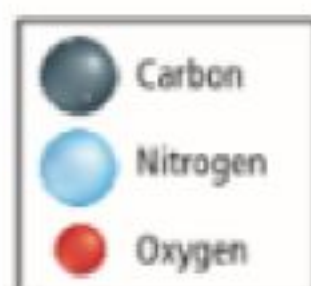
طاقة التنشيط في الشكل (1) أكبر من طاقة التنشيط في الشكل (2)

The activation energy in figure (1) equals the activation energy in figure (2)

طاقة التنشيط في الشكل (1) تُساوي طاقة التنشيط في الشكل (2)

Why the collision **fails** to produce a chemical reaction in the figure (d) below?

لماذا لا ينتج تفاعل كيميائي عن التصادم المبين في الرسم (d) أدناه؟

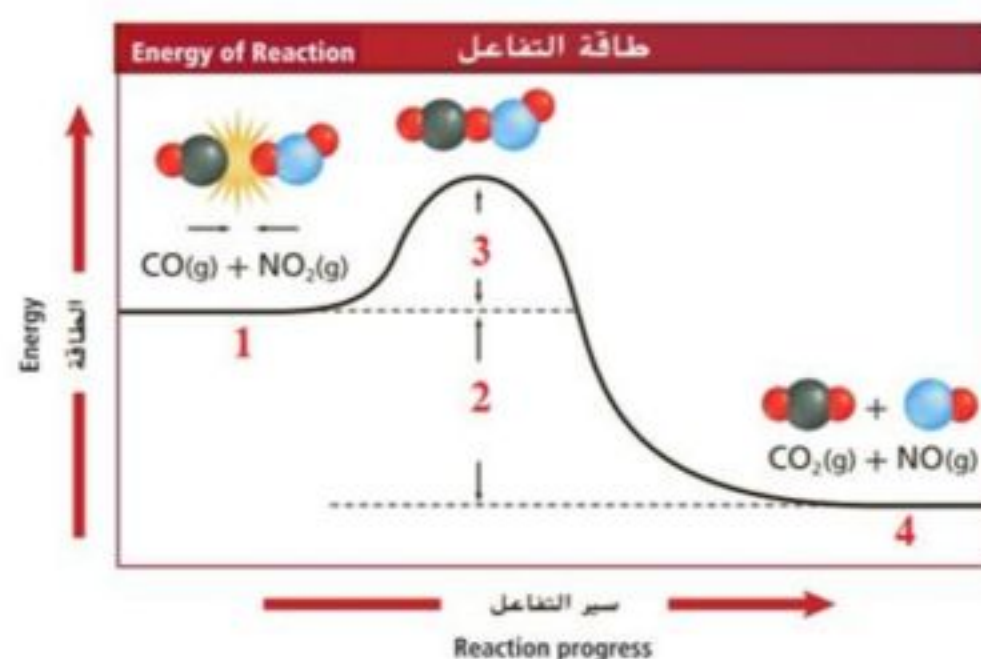


- A. Incorrect orientation
B. Correct orientation
C. Insufficient energy
D. Sufficient energy

- A. الاتجاه غير صحيح
B. الاتجاه صحيح
C. الطاقة غير كافية
D. الطاقة كافية



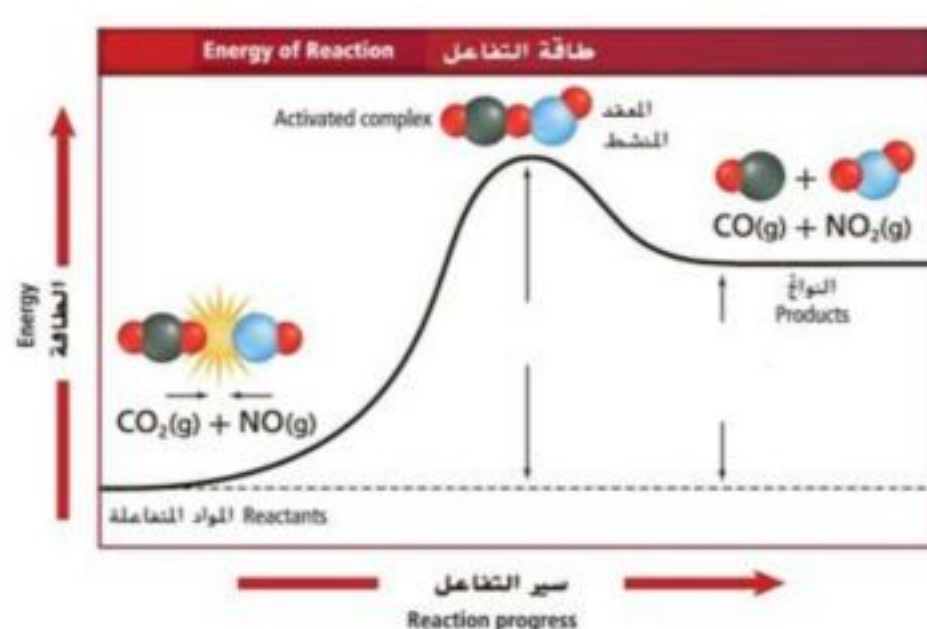
Which of the following is **correct** regarding the reaction represented by the graph below? أي مما يأتي **صحيح** فيما يتعلق بالتفاعل المُمثل بالرسم البياني أدناه؟



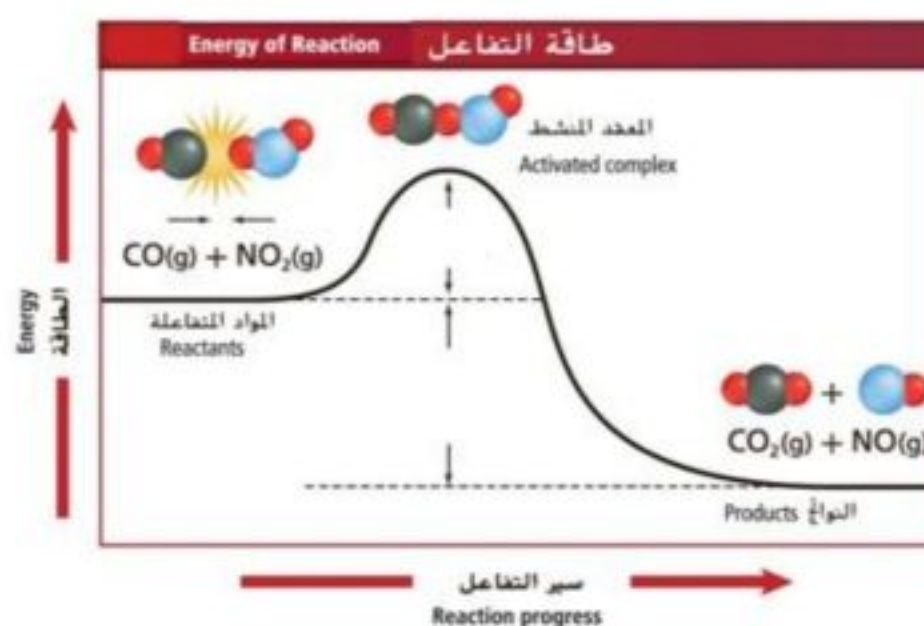
4	3	2	1	
الناتج Products	طاقة التنشيط Activation energy	الطاقة الناتجة عن التفاعل Energy released by reaction	المواد المتفاعلة Reactants	A
المواد المتفاعلة Reactants	الطاقة الناتجة عن التفاعل Energy released by reaction	طاقة التنشيط Activation energy	الناتج Products	B
المواد المتفاعلة Reactants	طاقة التنشيط Activation energy	الناتج Products	الطاقة الناتجة عن التفاعل Energy released by reaction	C
الطاقة الناتجة عن التفاعل Energy released by reaction	الناتج Products	المواد المتفاعلة Reactants	طاقة التنشيط Activation energy	D

Which of the following is **correct** regarding the two figures (1 and 2) below?

أي مما يلي **صحيح** فيما يتعلق بالشكلين (1 و 2) أدناه؟



الشكل 2 Figure 2



الشكل 1 Figure 1

In figure 1 the reactant molecules collide with enough energy to overcome the activation energy barrier and form **higher** energy products

في الشكل 1 تتصادم جزيئات المتفاعلات بطاقة كافية للتغلب على حاجز طاقة التنشيط وتكون النواتج عند مستوى طاقة أكبر

The activation energy in figure 1 **larger** than activation energy in figure 2

طاقة التنشيط في الشكل 1 أكبر من طاقة التنشيط في الشكل 2

The reaction in figure 2 is exothermic, while the reaction in figure 1 it is endothermic

التفاعل في الشكل 2 طارد للحرارة، بينما التفاعل في الشكل 1 ماص للحرارة

In figure 2 the reactant molecules absorb enough energy to overcome the activation energy barrier and form **higher** energy products

في الشكل 2 تمتص جزيئات المتفاعلات طاقة كافية للتغلب على حاجز طاقة التنشيط وتشكل نواتج ذات طاقة أكبر



First-order reaction rate laws

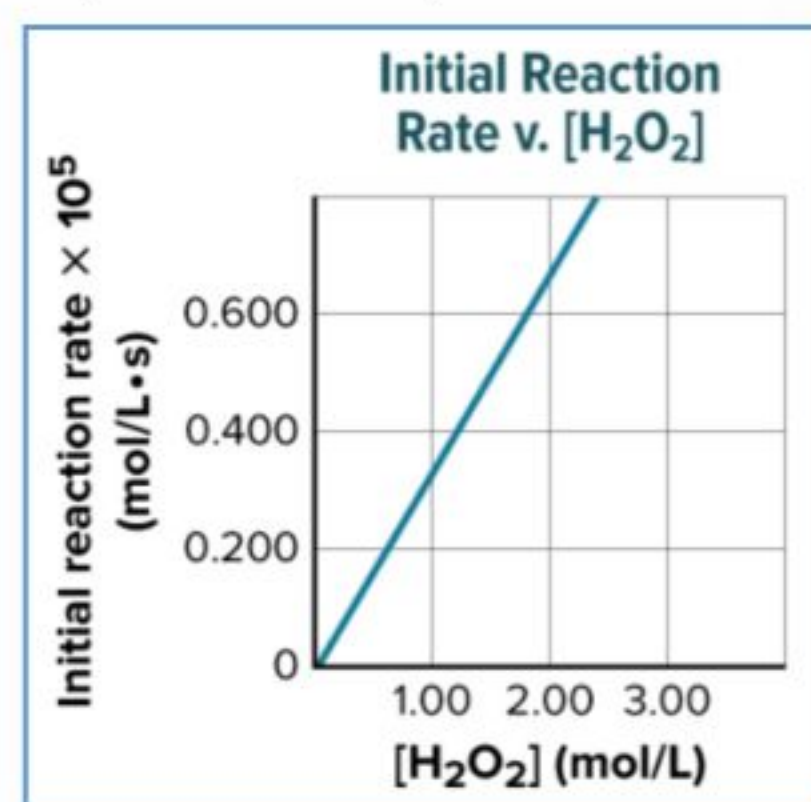
$$\text{Rate} = k[A] \rightarrow \text{Rate} = k[A]^1$$

The **reaction order** for a reactant defines how the rate is affected by the concentration of that reactant.

Rate = $k[\text{H}_2\text{O}_2]$. The decomposition of H_2O_2 is said to be **first order** in H_2O_2 . What does it mean?

The graph shows a direct relationship between the concentration of H_2O_2 and the rate of the decomposition. Complete this table.

$[\text{H}_2\text{O}_2]$ (mol/L)	Initial reaction rate $\times 10^5$ (mol/L.s)
1.00	
2.00	
3.00	



The rate constant, k , is equal to the of the line.

Get It?

If the reaction order for a reactant is first order, how will the rate of the reaction change if the concentration of the reactant is **tripled**?

Other-order reaction rate laws

The **overall reaction order** of a chemical reaction is the **sum** of the orders for the individual reactants.

Many chemical reactions, particularly those that have more than one reactant, are not first-order.

Consider this general form



a and b are coefficients

The General Rate Law

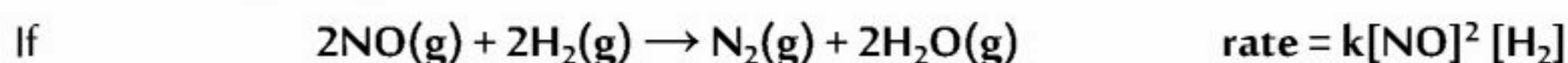
$$\text{rate} = k[A]^m[B]^n$$

$[A]$ and $[B]$ represent the concentrations of reactants A and B. The exponents m and n are the reaction orders.

The rate of a reaction is equal to the product of k and the concentrations of the reactants each raised to a power (order) that is determined experimentally.

If the reaction between A and B occurs in a single step (and with a single activated complex) does $m = a$ and $n = b$.

However, single-step reactions are not common.



Is it a single step reaction? because

The reaction is described as order in NO, order in H_2 , and order overall.

If $[\text{NO}]$ doubles, the rate If $[\text{H}_2]$ doubles, the rate

If one of the reactants is not part of the rate law expression, changing the concentration of that reactant will have no effect on the rate of the reaction. The exponent of this type of reactant would be and it's not written in the rate law expression.



Practice

Assume that the rate law for a generic chemical reaction is $\text{rate} = [\text{A}][\text{B}]^3$. What is the reaction order in A, the reaction order in B, and the overall reaction order?

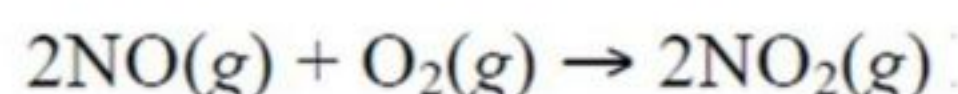
Consider the generic chemical reaction: $\text{A} + \text{B} \rightarrow \text{AB}$. Based on experimental data, the reaction is second order in Reactant A. If the concentration of A is halved, and all other conditions remain unchanged, how does the reaction rate change?

Suppose that a generic chemical reaction has the rate law of $\text{rate} = [\text{A}]^2[\text{B}]^3$ and that the reaction rate under a given set of conditions is $4.5 \times 10^{-4} \text{ mol}/(\text{L} \cdot \text{min})$. If the concentrations of both A and B are doubled and all other reaction conditions remain constant, how will the reaction rate change?





The chemical reaction :



التفاعل الكيميائي:

has the following rate law $\text{Rate} = k[\text{NO}]^2[\text{O}_2]$

if the concentration of NO decreases by half, what happens to the reaction rate?

له قانون السرعة التالي $\text{Rate} = k[\text{NO}]^2[\text{O}_2]$

إذا نقص تركيز NO إلى النصف، ماذا يحدث لـ سرعة التفاعل ؟

Reduces to one-half

تنقص إلى النصف

Becomes double

تُصبح الضعف

Reduces to one-quarter

تنقص إلى الربع

Remains the same

تبقى كما هو

The rate law for a certain reaction:

is $\text{Rate} = k[\text{A}][\text{B}]^2$

if the concentration of B is **halved**, and all other conditions remain unchanged, **how does the reaction rate change?**

قانون السرعة لتفاعل ما:

هو $\text{Rate} = k[\text{A}][\text{B}]^2$

إذا قل تركيز B إلى **النصف** وبقيت كل الظروف الأخرى ثابتة ، **كيف تتغير سرعة التفاعل ؟**

Decreases to a quarter of the initial reaction rate value

تقل إلى ربع قيمة السرعة الابتدائية

Quadruples (increases 4 times)

تتضاعف أربع مرات

Decreases to half of the initial reaction rate value

تقل إلى نصف قيمة السرعة الابتدائية

Doubles

تتضاعف

The rate law for the decomposition of H_2O_2 is expressed by

$$\text{Rate} = k[\text{H}_2\text{O}_2]^1$$

How the chemical rate changes if the H_2O_2 concentration decreases to one-half?

- A. Increases by one and half
- B. decreases by one-half
- C. Increase by one-half
- D. No change

يُعبّر عن قانون سرعة تفاعل تفكك H_2O_2 بالمعادلة التالية:

$$\text{Rate} = k[\text{H}_2\text{O}_2]^1$$

كيف تتغير سرعة التفاعل إذا انخفض تركيز H_2O_2 إلى النصف؟

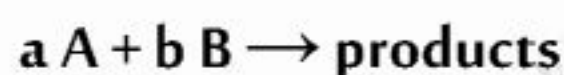
- A. تزداد بمعدل مرة ونصف
- B. تقل بمعدل النصف
- C. تزداد بمعدل النصف
- D. لا تتغير



Determine Reaction Order

The **method of initial rates** determines reaction order by comparing the initial rates of a reaction carried out with varying reactant concentrations.

Consider the general reaction



Trial	Initial [A] (M)	Initial [B] (M)	Initial Rate (mol/(L·s))
1	0.100	0.100	2.00×10^{-3}
2	0.200	0.100	4.00×10^{-3}
3	0.200	0.200	1.60×10^{-2}

$$\text{rate} = k[A]^m[B]^n$$

We need to find the exponents of [A] and [B] by choosing two trials to compare each time.

To find the exponent of [A]. In which trials we can see [B] remains constant?

Divide the higher by the lower in both concentration and rate. **(Change in [A])^m = (change in rate)**. Determine m

To find the exponent of [B]. In which trials we can see [A] remains constant?

Divide the higher by the lower in both concentration and rate. **(Change in [B])ⁿ = (change in rate)**. Determine n

Write the rate law now:

The overall reaction order is

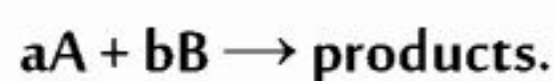
Practice problems:

Write the rate law for the reaction $aA \rightarrow bB$ if the reaction is third order in A. [B] is not part of the rate law.

The rate law for the reaction $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ is first order in O_2 and third order overall. What is the rate law for the reaction?



Given the experimental data below, use the method of initial rates to determine the rate law for the reaction



Trial	Initial [A](M)	Initial [B](M)	Initial Rate (mol/(L.s))
1	0.100	0.100	2.00×10^{-3}
2	0.200	0.100	2.00×10^{-3}
3	0.200	0.200	4.00×10^{-3}

22. CHALLENGE The rate law for the reaction $\text{CH}_3\text{CHO(g)} \rightarrow \text{CH}_4\text{(g)} + \text{CO(g)}$ is given by the following expression:

$$\text{Rate} = k[\text{CH}_3\text{CHO}]^2.$$

Use this information to fill in the missing experimental data below.

Trial	Initial $[\text{CH}_3\text{CHO}](M)$	Initial Rate (mol/(L.s))
1	2.00×10^{-3}	2.70×10^{-11}
2	4.00×10^{-3}	1.08×10^{-10}
3	8.00×10^{-3}	
4	6.00×10^{-3}	
5		6.75×10^{-10}
6		9.72×10^{-10}

بطاقة الكيمياء

صف 12 متقدم

شرح أ. طارق محمد



جاهز للنجاح وإطلاق إبداعاتك



فيديوهات ▶ ملازم شرح ▶ أوراق عمل ▶ اختبارات

مراجعة تفصيلية شاملة للهيكل

للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493



Practice

The instantaneous rate data in **Table 3** were obtained for the reaction $\text{H}_2(\text{g}) + 2\text{NO}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{N}_2\text{O}(\text{g})$ at a given temperature and concentration of NO. How does the instantaneous rate of this reaction change as the initial concentration of H_2 is changed? Based on the data, is $[\text{H}_2]$ part of the rate law? Explain.

Table 3 Reaction Between $\text{H}_2(\text{g})$ and $\text{NO}(\text{g})$

$[\text{H}_2]$ (mol/L)	Instantaneous Rate (mol/L.s)
0.18	6.00×10^{-3}
0.32	1.07×10^{-2}
0.58	1.93×10^{-2}

The experimental data in **Table 4** were obtained for the decomposition of azomethane ($\text{CH}_3\text{N}_2\text{CH}_3$) at a particular temperature according to the equation $\text{CH}_3\text{N}_2\text{CH}_3(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g}) + \text{N}_2(\text{g})$. Use the data to determine the reaction's experimental rate law.

Table 4 Decomposition of Azomethane

Experiment Number	Initial $[\text{CH}_3\text{N}_2\text{CH}_3]$	Initial Reaction Rate
1	0.012M	$2.5 \times 10^{-6} \text{ mol/(L} \cdot \text{s)}$
2	0.024M	$5.0 \times 10^{-6} \text{ mol/(L} \cdot \text{s)}$

Use the data in **Table 4** to calculate the value of the specific rate constant, k .

At the same temperature, predict the reaction rate when the initial concentration of $\text{CH}_3\text{N}_2\text{CH}_3$ is 0.048M. Use the data in **Table 4**.



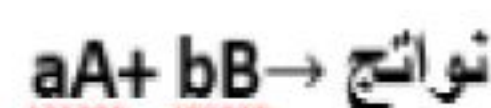
Given the experimental data below, use the method of initial rates to determine the reaction order.



Experimental Data

Trial	Initial [A](M)	Initial [B](M)	Initial Rate (mol/(L.s))
1	0.100	0.100	2.00×10^{-3}
2	0.200	0.100	2.00×10^{-3}
3	0.200	0.200	4.00×10^{-3}

بمعرفة البيانات التجريبية أدناه، استخدم طريقة السرعات الابتدائية لتحديد الرتبة الكلية للتفاعل:



البيانات التجريبية

تجربة	التركيز الابتدائي [A](M)	التركيز الابتدائي [B](M)	السرعة الابتدائية (mol/(L.s))
1	0.100	0.100	2.00×10^{-3}
2	0.200	0.100	2.00×10^{-3}
3	0.200	0.200	4.00×10^{-3}

- A. 1
B. 2
C. 3
D. 4

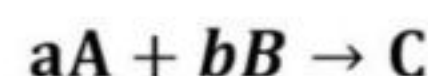
1. A
2. B
3. C
4. D

Use the experimental data in the following table.

استخدم البيانات التجريبية في الجدول التالي .

What is the rate law for the reaction?

ما قانون السرعة للتفاعل؟



البيانات التجريبية Experimental Data

السرعة الابتدائية Initial Rate mol/(L.s)	التركيز الابتدائي Initial concentration [B] (M)	التركيز الابتدائي Initial concentration [A] (M)	التجربة Trial
8×10^{-8}	2.4	1.2	1
4×10^{-8}	1.2	1.2	2
7.2×10^{-7}	2.4	3.6	3

$$\text{Rate} = k[A]^2$$

$$\text{Rate} = k[A][B]$$

$$\text{Rate} = k[A]^2[B]$$

$$\text{Rate} = k[A][B]^2$$



Given the experimental data in the table below and using the method of initial rates.

بمعرفة البيانات التجريبية في الجدول أدناه ومستخدمًا طريقة السرعات الابتدائية.

What is the rate law for the following reaction?

ما قانون سرعة التفاعل التالي؟

(تلميح: أي عدد يكون الأس الخاص به صفرًا يساوي 1)

(Hint: Any number to the zero power equals one)

$aA + bB \rightarrow \text{products}$ (نواتج)			
Experimental Data		البيانات التجريبية	
السرعة الابتدائية Initial Rate mol/(L.s)	التركيز الابتدائي Initial concentration [B] (M)	التركيز الابتدائي Initial concentration [A] (M)	تجربة Trial
2.00×10^{-3}	0.100	0.100	1
2.00×10^{-3}	0.100	0.200	2
4.00×10^{-3}	0.200	0.200	3

$$\text{Rate} = k [A] [B]$$

$$\text{Rate} = k [A]^2 [B]$$

$$\text{Rate} = k [A]$$

$$\text{Rate} = k [B]$$

Using the experimental data in the following table, what is the rate law for the reaction?

مستخدمًا البيانات التجريبية في الجدول التالي، ما قانون السرعة للتفاعل؟

$aA + bB \rightarrow \text{products}$			
السرعة الابتدائية Initial Rate (mol/(L.s))	التركيز الابتدائي Initial concentration [B] (M)	التركيز الابتدائي Initial concentration [A] (M)	التجربة Trial
3.00×10^{-3}	0.273	0.273	1
3.00×10^{-3}	0.273	0.546	2
6.00×10^{-3}	0.546	0.546	3

$$\text{Rate} = k[A]$$

$$\text{Rate} = k[A][B]$$

$$\text{Rate} = k[A]^2[B]$$

$$\text{Rate} = k[B]$$



Write is the rate law for the following reaction

اكتب قانون سرعة التفاعل.

aA + bB + cC -----> Products (النواتج)				
السرعة الابتدائية Initial Rates	[C] التركيز Concentration	[B] التركيز Concentration	[A] التركيز Concentration	تجربة Trial
3	0.4	0.763	0.273	1
9	0.4	0.763	0.819	2
12	0.4	1.526	0.273	3
6	0.8	0.763	0.273	4

$$\text{Rate} = [A]^2 [B]^2 [C]^2$$

$$\text{Rate} = [A] [B]^2 [C]^2$$

$$\text{Rate} = [A] [B] [C]^2$$

$$\text{Rate} = [A] [B]^2 [C]$$

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The reaction $A \rightarrow B$ is a one-step reaction.

One-Step Reaction Rate Law

$$\text{rate} = k[A] \quad [A] \text{ represents the concentration of a reactant; } k \text{ is a constant.}$$

The rate of a one-step reaction is the product of the concentration of the reactant and a constant

The symbol k is the **specific rate constant**, a numerical value that relates the reaction rate and the concentrations of reactants at a given temperature.

- K is unique for every reaction.
- K can have a variety of units including $L/(\text{mol}\cdot\text{s})$, $L^2/(\text{mol}^2\cdot\text{s})$, and s^{-1} . This unit depends on the reaction order.

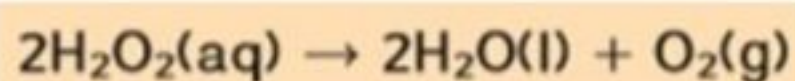
The unit of the rate is concentration/time, consider the concentration is M or mol/L . Complete the table

Rate law	Reaction order	Unit of K
$\text{Rate} = K[A]^0$		
$\text{Rate} = K[A]$		
$\text{Rate} = K[A]^2$		
$\text{Rate} = K[A]^3$		

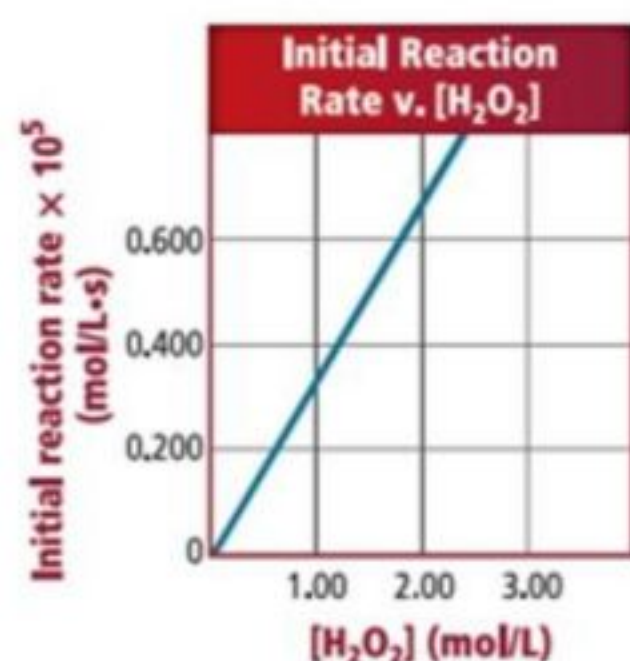
- The rate law shows that the reaction rate is proportional to the molar concentration of A .
- K does not change with concentration; however, k does change with temperature.
- A large value of K means that



The following decomposition reaction:



is first order, and the graph below shows relationship between its rate of decomposition and its concentration, when $[\text{H}_2\text{O}_2]$ equals 1.50 mol/L. Which of the following is the **correct unit** of the specific rate constant **k**?

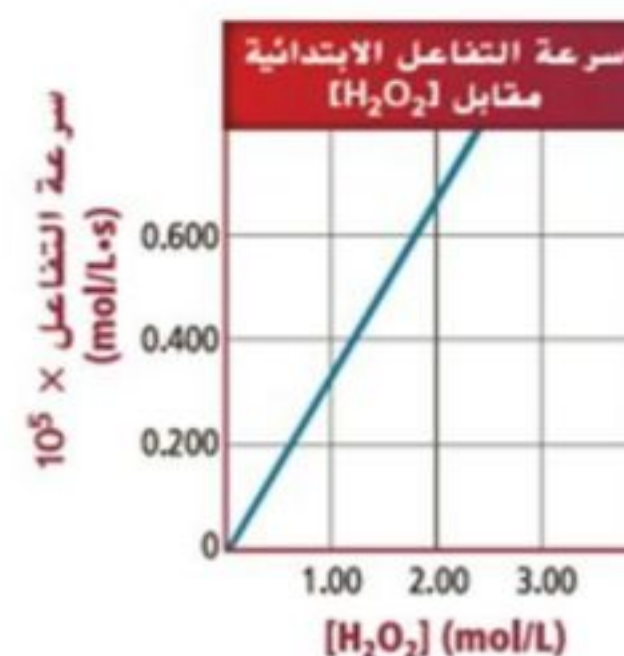


L/(mol.s)

L²/ (mol².s)

s⁻¹

s



s

Which of the following is **not true** about the specific rate constant (K)?

- a- It's unique for every reaction and has a variety of units.
- b- It changes when concentration changes
- c- It changes when temperature changes
- d- It has a large value when the reaction is fast

أي مما يلي **ليس صحيحا** فيما يتعلق بثابت السرعة النوعية (K)؟

- a- مميز لكل تفاعل وله وحدات مختلفة
- b- يتغير بتغير التركيز
- c- يتغير بتغير درجة الحرارة
- d- له قيمة كبيرة عندما يكون التفاعل سريع

What is the unit of the specific rate constant K for a reaction that has the rate law: $\text{Rate} = K[\text{A}]^2[\text{B}]$

- a- s⁻¹
- b- L³/(mol³.s)
- c- L²/(mol².s)
- d- Mol/L.s

ما هي وحدة ثابت السرعة النوعية (K) للتفاعل الذي له قانون السرعة $\text{Rate} = K[\text{A}]^2[\text{B}]$ ؟

- a- s⁻¹
- b- L³/(mol³.s)
- c- L²/(mol².s)
- d- Mol/L.s



22	CHM.5.4.01.020.08 Calculate the instantaneous rate of a reaction from experimental data - calculate the concentration of a reactant using the instantaneous rate of a reaction	Textbook + Example problem 2 + Practice problems	67, 68
23	CHM.5.4.01.020.08 Calculate the instantaneous rate of a reaction from experimental data	Textbook + Example problem 2 + Practice problems	67, 68

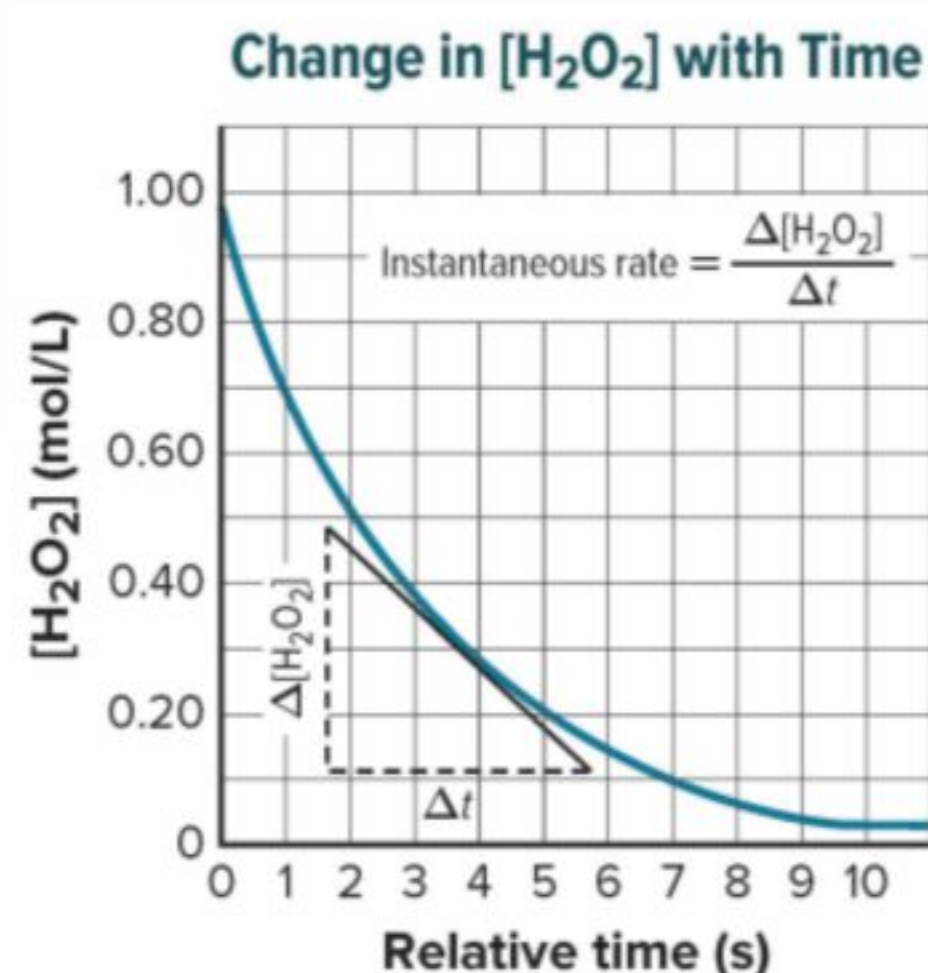
Instantaneous Reaction Rates

The **instantaneous rate** is the reaction rate at a specific time. It is the slope of the straight line tangent to the curve at a specific time.

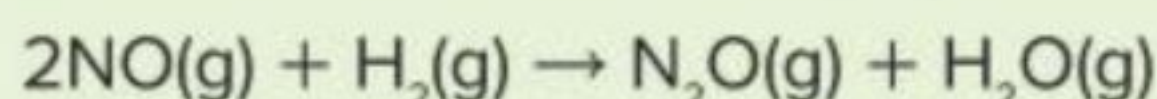
The rate of change in H_2O_2 concentration relates to one specific point (or instant) on the graph.

The instantaneous rate also can be determined if you know the experimentally determined rate law and the specific rate constant.

Graph check: Identify the variables that are plotted on the x-axis and on the y-axis.



CALCULATE INSTANTANEOUS REACTION RATES The following reaction is first order in H_2 and second order in NO with a rate constant of $2.90 \times 10^2 \text{ (L}^2/(\text{mol}^2 \cdot \text{s}))$.



Calculate the instantaneous rate when the reactant concentrations are $[\text{NO}] = 0.00200\text{M}$ and $[\text{H}_2] = 0.00400\text{M}$.

In Problems 31 and 32, use the concentrations given to calculate the instantaneous rates for the reaction between NO and H_2 . Use the rate law from Example Problem 2.

31. $[\text{NO}] = 0.00500\text{M}$ and $[\text{H}_2] = 0.00200\text{M}$

32. $[\text{NO}] = 0.0100\text{M}$ and $[\text{H}_2] = 0.00125\text{M}$

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CHALLENGE Calculate $[\text{NO}]$ for the reaction in Example Problem 2 if the rate is $9.00 \times 10^{-5} \text{ mol/(L} \cdot \text{s)}$ and $[\text{H}_2]$ is 0.00300M .

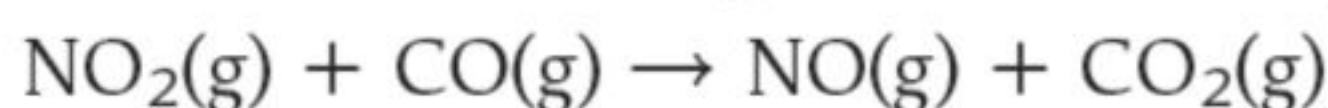


Extra Practice_Final Exam Questions

Calculate A reaction between A and B to form AB is first order in A and first order in B. The rate constant, k , equals $0.500 \text{ mol}/(\text{L}\cdot\text{s})$. What is the rate of the reaction when $[A] = 2.00 \times 10^{-2} \text{ M}$ and $[B] = 1.50 \times 10^{-2} \text{ M}$?

Dinitrogen pentoxide decomposes in chloroform at a rate of $2.48 \times 10^{-4} \text{ mol}/(\text{L}\cdot\text{min})$ at a particular temperature according to the equation $2\text{N}_2\text{O}_5 \rightarrow 4\text{NO}_2 + \text{O}_2$. The reaction is first order in N_2O_5 . Given an initial concentration 0.400 mol/L , what is the rate constant for the reaction? What is the approximate $[\text{N}_2\text{O}_5]$ after the reaction proceeds for 1.30 h ?

Automobile Engine The following reaction takes place in an automobile's engine and exhaust system.



The reaction's rate law at a particular temperature is $\text{Rate} = 0.50 \text{ L}/(\text{mol}\cdot\text{s})[\text{NO}_2]^2$. What is the reaction's initial, instantaneous rate when $[\text{NO}_2] = 0.0048 \text{ mol/L}$?

The rate law for the reaction: $A + B + C \rightarrow \text{products}$ is :

$$\text{Rate} = k[\text{B}]^2[\text{C}]$$

If $k = 6.92 \times 10^{-5} \text{ L}^2/(\text{mol}^2\cdot\text{s})$

and $[\text{A}] = 0.175 \text{ M}$, $[\text{B}] = 0.230 \text{ M}$, $[\text{C}] = 0.315 \text{ M}$.

What is the instantaneous reaction rate?

قانون السرعة للتفاعل : $A + B + C \rightarrow \text{نواتج}$ هو :

$$\text{Rate} = k[\text{B}]^2[\text{C}]$$

إذا كان $k = 6.92 \times 10^{-5} \text{ L}^2/(\text{mol}^2\cdot\text{s})$

و $[\text{C}] = 0.315 \text{ M}$ ، $[\text{B}] = 0.230 \text{ M}$ ، $[\text{A}] = 0.175 \text{ M}$

ما هي سرعة التفاعل اللحظية؟

$$1.15 \times 10^{-6} \text{ mol}/(\text{L}\cdot\text{s})$$

$$8.77 \times 10^{-7} \text{ mol}/(\text{L}\cdot\text{s})$$

$$6.41 \times 10^{-7} \text{ mol}/(\text{L}\cdot\text{s})$$

$$5.01 \times 10^{-6} \text{ mol}/(\text{L}\cdot\text{s})$$





Reactant and Product Concentration v. Time

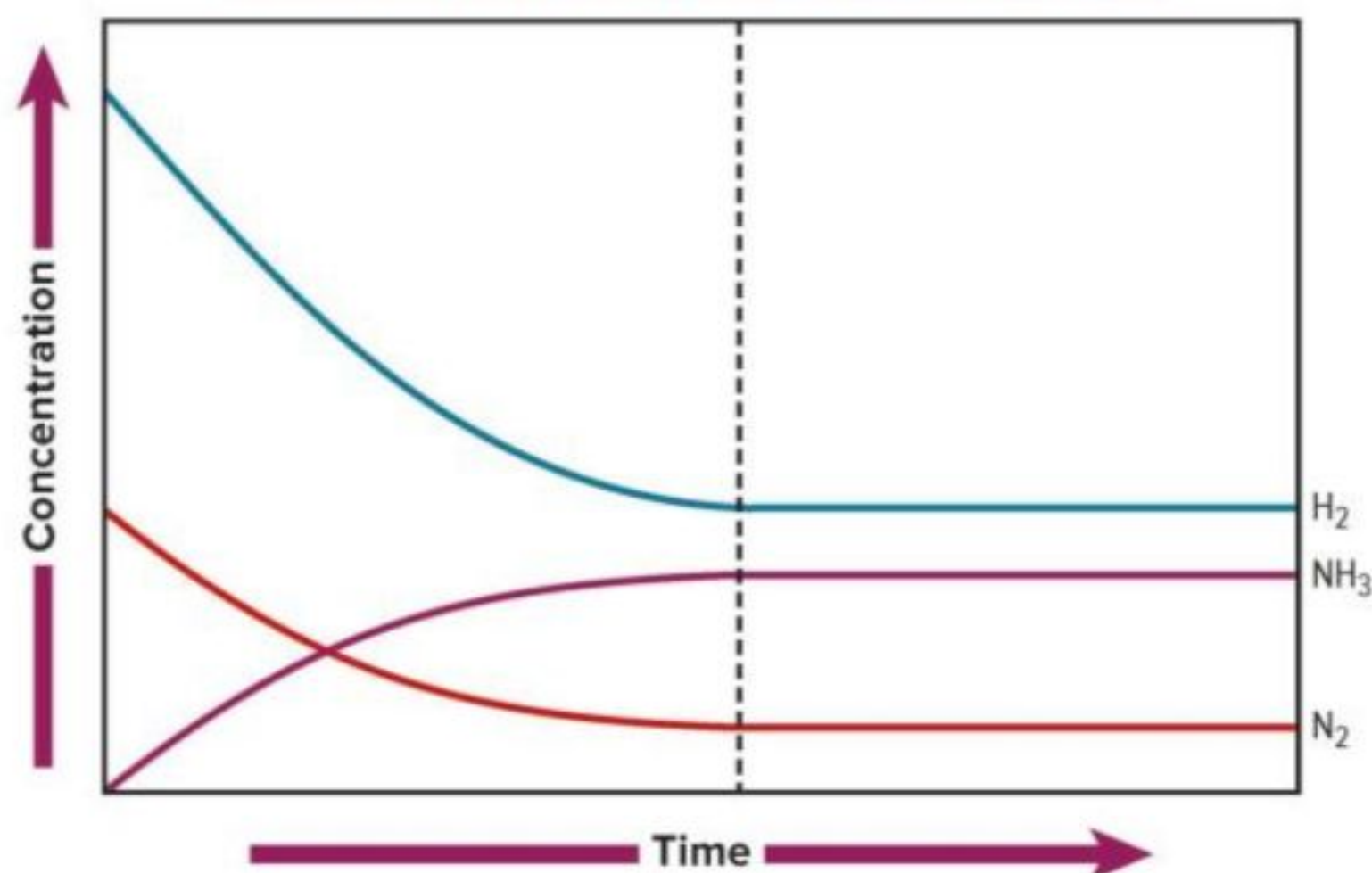


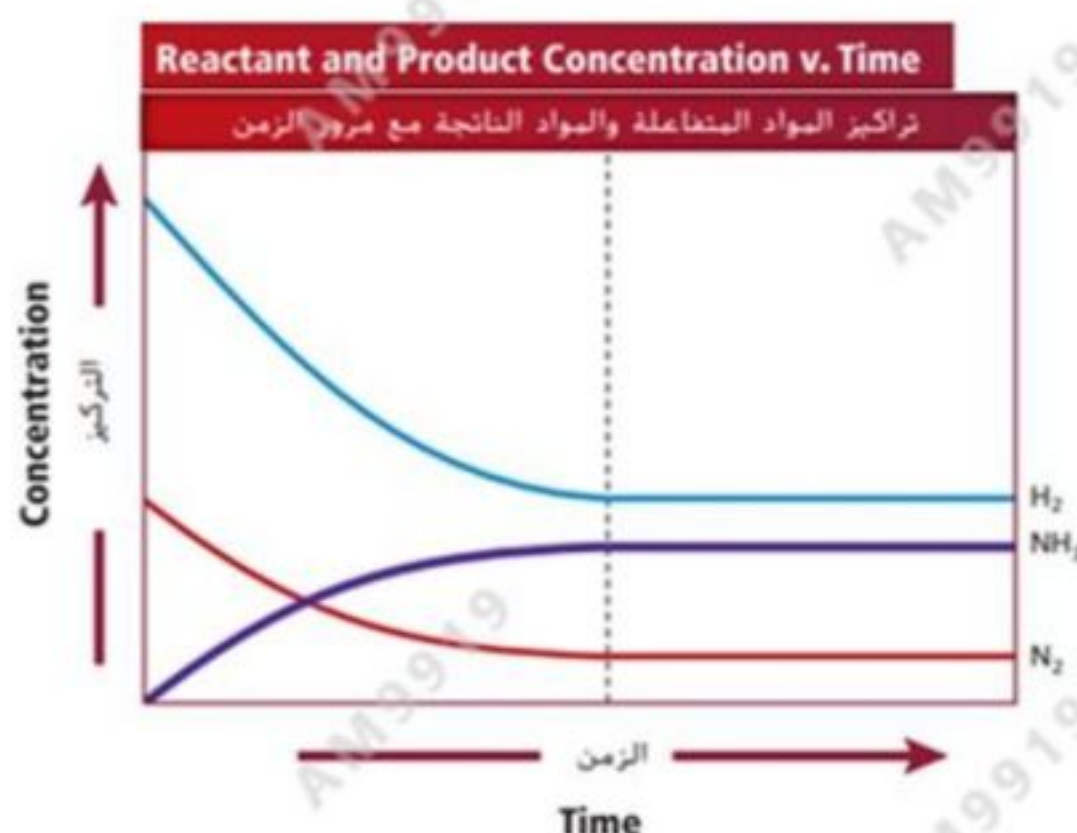
Figure 2 The concentrations of the reactants (H_2 and N_2) decrease at first, while the concentration of the product (NH_3) increases. Then, before the reactants are used up, all concentrations become constant.

Explain how the graph shows that the concentrations of the reactants and products become constant.

Describe the slopes of the curves for the reactants and for the product on the left of the vertical dotted line. How do the slopes differ on the right of the dotted line?

In the diagram below, what do the horizontal lines on the right side of the diagram mean?

في الرسم البياني أدناه ما دلالة الخطوط الأفقية في الجانب الأيمن من الرسم البياني؟



☐ The concentrations of N_2 and H_2 are zero

تراكيز H_2 و N_2 تساوي صفراً

☐ The concentrations of H_2 , N_2 and NH_3 become constant

تصبح تراكيز H_2 و N_2 و NH_3 ثابتة

☐ All the reactants are converted into products

تم تحويل كل المواد المتفاعلة إلى مواد ناتجة

☐ H_2 , N_2 and NH_3 concentrations continue to change

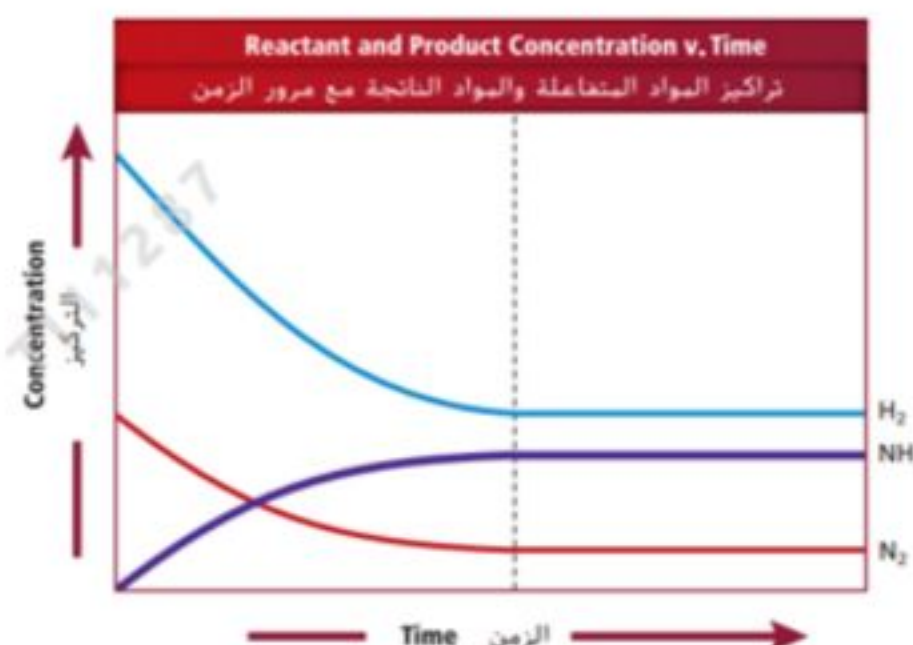
تستمر تراكيز H_2 و N_2 و NH_3 في التغير



The graph below shows the change in the concentrations of reactants, and products during the reaction of nitrogen and hydrogen to form ammonia.

Which of the following is **correct**?

يُظهر الرسم البياني أدناه تغير تراكيز المواد المتفاعلة والناجمة خلال تفاعل النيتروجين والهيدروجين لإنتاج الأمونيا. أي مما يأتي **صحيح**؟



The concentrations of the reactants decrease at first

تتناقص تراكيز المواد المتفاعلة في البداية

The concentrations of the reactants increase at first

تتزايد تراكيز المواد المتفاعلة في البداية

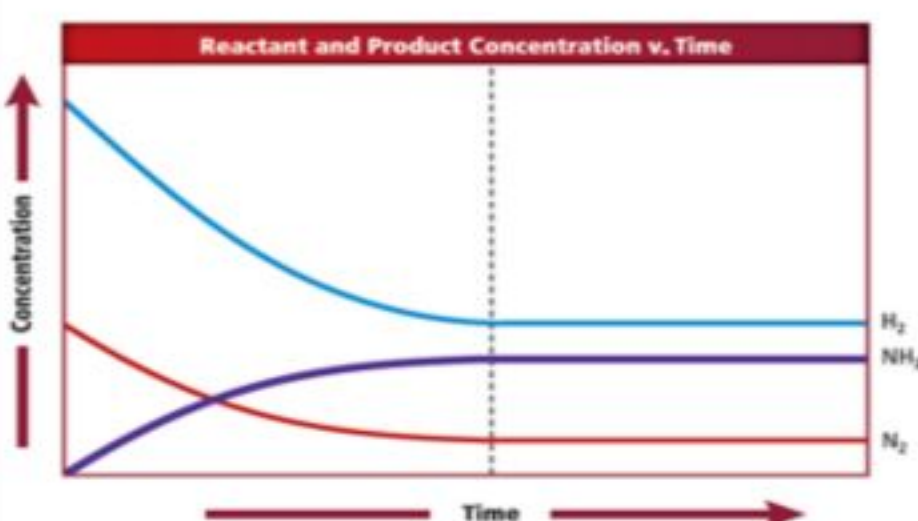
At equilibrium, the concentrations of products decrease

عند الاتزان تتناقص تراكيز المواد الناجمة

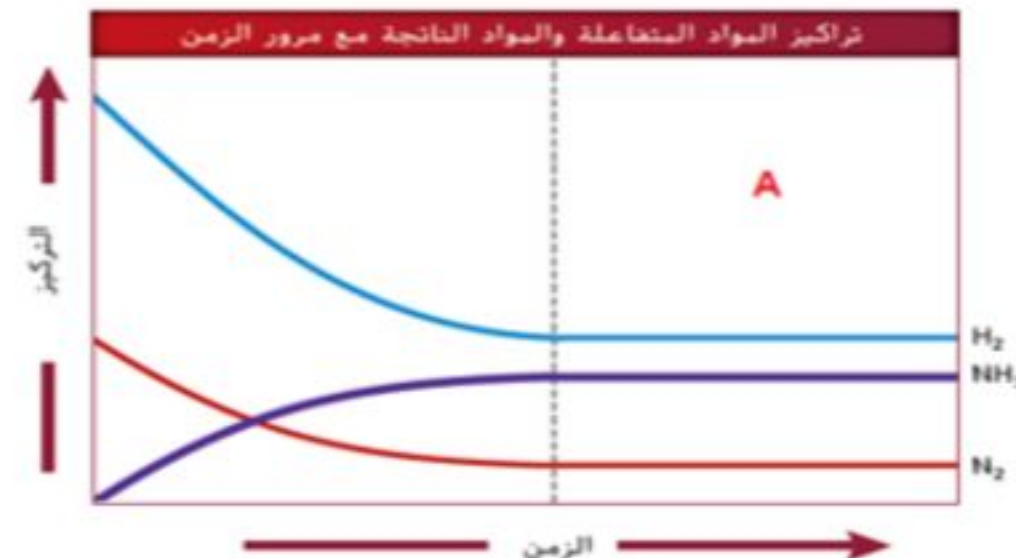
At equilibrium, the concentrations of products increase

عند الاتزان تتزايد تراكيز المواد الناجمة

In the figure below, in the area indicated by the symbol A is



في الشكل أدناه، في المنطقة المشار إليها بالرمز A يكون



A - The concentration of the products equals the concentration of the reactants

A - تركيز المواد الناجمة يساوي تركيز المواد المتفاعلة

B - The concentration of both reactants and products remains constant

B - تراكيز المواد المتفاعلة والمواد الناجمة ثابتة

C - The concentration of the reactants decreases and the concentration of the products increases

C - تتناقص تراكيز المواد المتفاعلة وتزداد تراكيز المواد الناجمة

D - The concentration of the reactants increases and the concentration of the products decreases

D - تزداد تراكيز المواد المتفاعلة وتتناقص تراكيز المواد الناجمة



Which of the following represents a chemical equilibrium state?

أي مما يأتي يُمثل حالة الاتزان الكيميائي؟

The reverse reaction happens faster than the forward reaction

يحدث التفاعل العكسي أسرع من التفاعل الأمامي



Both the forward and reverse reactions have stopped

يتوقف كل من التفاعلين الأمامي والعكسي



The forward reaction and the reverse reaction happen at the same rate

يحدث التفاعل الأمامي والتفاعل العكسي بالسرعة نفسها



The forward reaction happens faster than the reverse reaction

يحدث التفاعل الأمامي أسرع من التفاعل العكسي



Which of the following is **NOT** a characteristic of chemical reactions that reach equilibrium?

أي مما يلي **ليس** من خصائص التفاعلات الكيميائية التي تصل إلى حالة اتزان؟

The temperature must remain constant

يجب أن تبقى درجة الحرارة ثابتة



All reactants and products are present, and they are in constant dynamic motion

يجب أن تبقى المواد المتفاعلة والمواد الناتجة معاً في حركة ديناميكية دائمة



The reaction must take place in a closed system

يجب أن يحدث التفاعل في نظام مغلق



The reactants and products must be in similar physical state

يجب أن تكون المواد المتفاعلة والمواد الناتجة في حالة فيزيائية متشابهة



ACADEMY
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Tarek Mohamed

Tarek Mohamed

Tarek Mohamed

Tarek Mohamed





Equilibrium Constant Expressions for Heterogeneous Equilibria

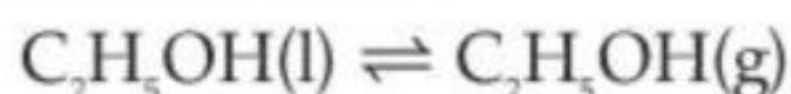
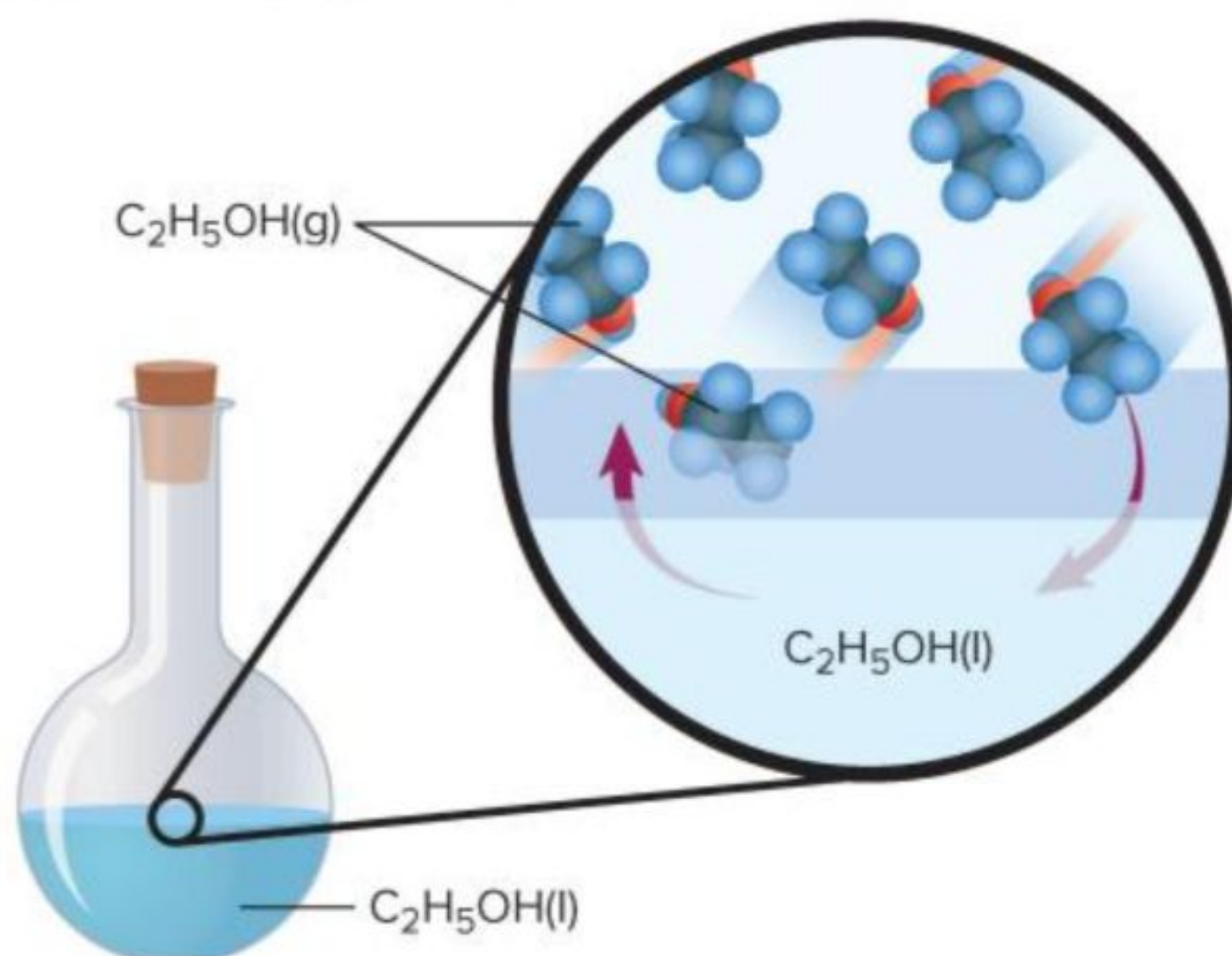


Figure 8 At equilibrium the rate of evaporation of ethanol ($\text{C}_2\text{H}_5\text{OH}$) equals the rate of condensation. This two-phase equilibrium is called a heterogeneous equilibrium. K_{eq} depends only on $[\text{C}_2\text{H}_5\text{OH}(\text{g})]$.

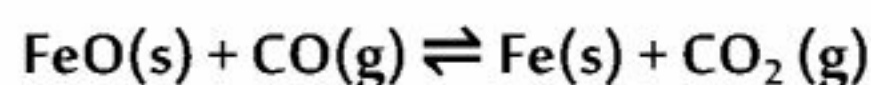
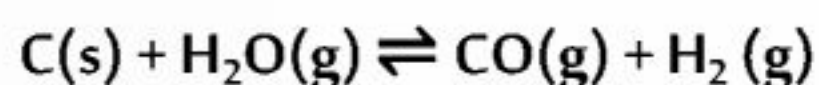
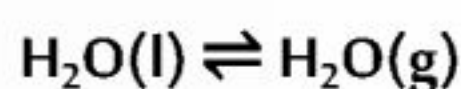
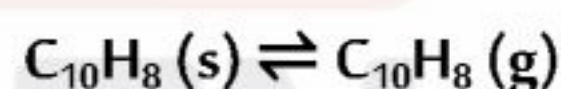
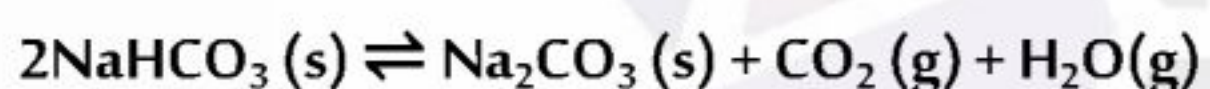


K_{eq} =

This reaction is a **heterogeneous equilibrium**, why?

Liquids and solids are pure substances with unchanging concentrations so the equilibrium constant, K_{eq}, depends only on the concentration of gases.

Write equilibrium constant expressions for these heterogeneous equilibria.

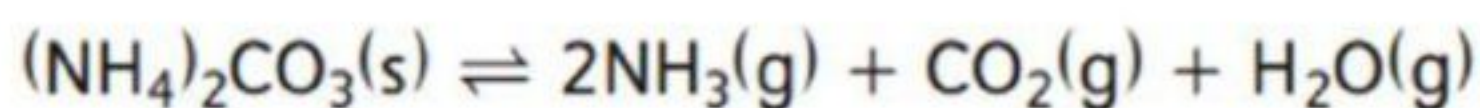


CHALLENGE Solid iron reacts with chlorine gas to form solid iron(III) chloride (FeCl_3). Write the balanced equation and the equilibrium constant expression for the reaction.



Which equilibrium constant expression k_{eq} **doesn't** represent the corresponding balanced chemical equation?

أي تعبير ثابت الاتزان k_{eq} **لا** يمثل المعادلة الكيميائية الموزونة المقابلة له؟



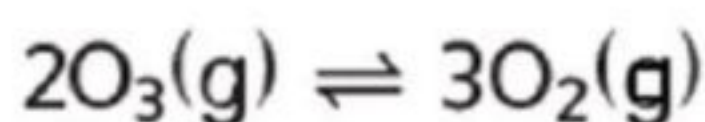
$$k_{eq} = [NH_3]^2[CO_2][H_2O]$$



$$k_{eq} = [CO_2]$$



$$k_{eq} = \frac{[NbCl_5][NbCl_3]}{[NbCl_4]^2}$$



$$k_{eq} = \frac{[O_3]^2}{[O_2]^3}$$

In the following table, what is the **incorrect** equilibrium constant expression for the corresponding reaction?

في الجدول التالي، ما تعبير ثابت الاتزان **غير** الصحيح للتفاعل الذي يُقابلة؟

تعبير ثابت الاتزان equilibrium constant expression	التفاعل Reaction	
$K_{eq} = [C_2H_5OH(g)]$	$C_2H_5OH(l) \rightleftharpoons C_2H_5OH(g)$	1
$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	2
$\frac{[H_2]^2[H_2S]^2}{[S_2]}$	$2H_2S(g) \longrightarrow 2H_2(g) + S_2(g)$	3
$\frac{[N_2]^3[H_2O]^4}{[N_2H_4]^2[NO_2]^2}$	$2N_2H_4(g) + 2NO_2(g) \rightleftharpoons 3N_2(g) + 4H_2O(g)$	4



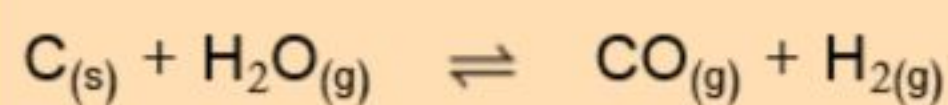
In the following table, what is the correct equilibrium constant expression for the corresponding reaction?

في الجدول التالي، ما تعبير ثابت الاتزان الصحيح للتفاعل الذي يُقابله؟

تعبير ثابت الاتزان	التفاعل	
$\frac{[H_2][I_2]}{[HI]^2}$	$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	A
$\frac{[Na_2CO_3][CO_2][H_2O]}{[NaHCO_3]^2}$	$2NaHCO_3(s) \rightleftharpoons Na_2CO_3(s) + CO_2(g) + H_2O(g)$	B
$\frac{[CH_4][H_2O]}{[CO][H_2]^3}$	$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$	C
$\frac{[CaCO_3]}{[CaO]}$	$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	D

What is the equilibrium constant expression for the following reaction?

ما تعبير ثابت الاتزان للتفاعل التالي؟



$$\frac{[CO][H_2]}{[C][H_2O]}$$

$$\frac{[H_2O]}{[CO][H_2]}$$

$$\frac{[C][H_2O]}{[CO][H_2]}$$

$$\frac{[CO][H_2]}{[H_2O]}$$

**Example problems:**

Calculate the value of K_{eq} for the equilibrium constant expression $K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$ given concentration data at one equilibrium position: $[NH_3] = 0.933 \text{ mol/L}$, $[N_2] = 0.533 \text{ mol/L}$, $[H_2] = 1.600 \text{ mol/L}$.

Calculate K_{eq} for the equilibrium in $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ using the data $[N_2O_4] = 0.0185 \text{ mol/L}$ and $[NO_2] = 0.0627 \text{ mol/L}$.

Calculate K_{eq} for the equilibrium in $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$ using the data $[CO] = 0.0613 \text{ mol/L}$, $[H_2] = 0.1839 \text{ mol/L}$, $[CH_4] = 0.0387 \text{ mol/L}$, and $[H_2O] = 0.0387 \text{ mol/L}$.

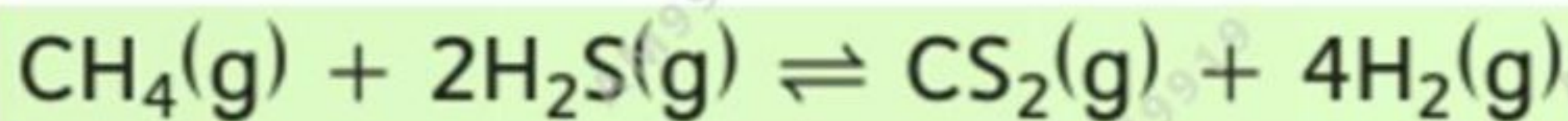
CHALLENGE The reaction $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$ reaches equilibrium at 900 K. K_{eq} is 8.2×10^{-2} . If the equilibrium concentrations of CO and Cl_2 are 0.150M, what is the equilibrium concentration of $COCl_2$?

Calculate Determine the value of K_{eq} at 400 K for this equation: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ if $[PCl_5] = 0.135 \text{ mol/L}$, $[PCl_3] = 0.550 \text{ mol/L}$, and $[Cl_2] = 0.550 \text{ mol/L}$.



The reaction below reaches equilibrium at a given temperature. Using the data in the following table, what is the concentration of H_2S ?

يصل التفاعل أدناه إلى حالة الاتزان عند درجة حرارة معينة. موطفاً بيانات الجدول التالي، ما تركيز الاتزان لـ H_2S ؟



$[H_2]$	$[CS_2]$	$[CH_4]$	ثابت الاتزان K_{eq} Equilibrium constant
0.0325 mol/L	0.455 mol/L	0.0820 mol/L	6.50×10^{-3}

0.0310

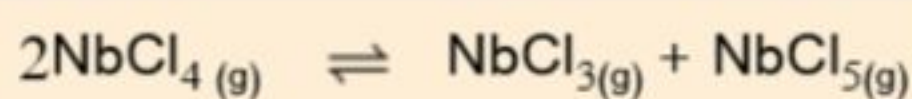
0.425

0.845

0.165

The reaction below reaches equilibrium at a certain temperature

يصل التفاعل أدناه إلى حالة الاتزان عند درجة حرارة معينة،



, $K_{eq} = 6.90 \times 10^{-4}$, If the equilibrium concentrations are:

و $K_{eq} = 6.90 \times 10^{-4}$ ، إذا كانت تراكيز الاتزان هي:

$NbCl_3 = 0.450 \text{ mol/L}$, $NbCl_5 = 0.0380 \text{ mol/L}$

What is the equilibrium concentration of $NbCl_4$?

فما تركيز الاتزان لـ $NbCl_4$ ؟

5.65 mol/L

4.98 mol/L

2.75 mol/L

1.69 mol/L

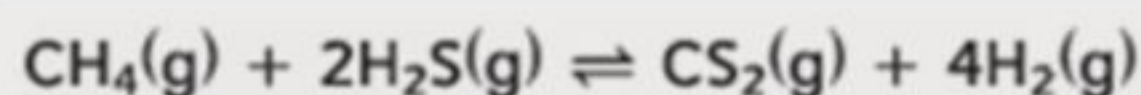


The following reaction reaches equilibrium. If you know that equilibrium constant K_{eq} of this reaction is 8.54 and the concentrations at equilibrium are as shown in the table below.

What is the equilibrium concentration of H_2S (mol/L)?

يصل التفاعل التالي إلى حالة الاتزان، إذا علمت أن ثابت الاتزان K_{eq} لهذا التفاعل هو 8.54 والتركيز عند الاتزان كما يتضح في الجدول أدناه:

فما تركيز الاتزان لـ H_2S بوحدة mol/L؟



$[CS_2]$	0.0375 mol / L
$[H_2]$	0.0450 mol / L
$[CH_4]$	0.0105 mol / L

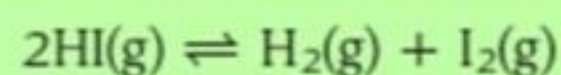
$$2.4 \times 10^{-5}$$

$$1.3 \times 10^{-3}$$

$$3.5 \times 10^{-4}$$

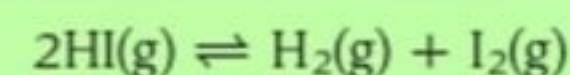
$$1.7 \times 10^{-6}$$

At 350°C, $k_{eq} = 1.67 \times 10^{-2}$ for the reversible reaction



What is the concentration of HI at equilibrium if $[H_2]$ is 2.44×10^{-3} M and $[I_2]$ is 7.18×10^{-5} M?

عند 350°C، $k_{eq} = 1.67 \times 10^{-2}$ للتفاعل الانعكاسي



ما تركيز HI عند الاتزان إذا كان مقدار $[H_2]$ هو 2.44×10^{-3} M ومقدار $[I_2]$ هو 7.18×10^{-5} M؟

$$3.24 \times 10^{-3} \text{ M}$$

$$1.05 \times 10^{-9} \text{ M}$$

$$3.99 \times 10^{-6} \text{ M}$$

$$1.75 \times 10^{-7} \text{ M}$$



The reaction $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$ reaches equilibrium. If the equilibrium concentrations are:

$$[\text{SO}_2] = 0.0170 \text{ mol / L}$$

$$[\text{O}_2] = 0.0230 \text{ mol / L}$$

K_{eq} is 4.32

What is the equilibrium concentration of SO_3 in mol / L

التفاعل $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$ يصل إلى حالة الاتزان، فإذا كانت التراكيز عند الاتزان هي:

$$[\text{O}_2] = 0.0230 \text{ mol / L} \text{ و } [\text{SO}_2] = 0.0170 \text{ mol / L}$$

و ثابت الاتزان K_{eq} لهذا التفاعل هو 4.32

فما تركيز الاتزان لـ SO_3 بوحدة mol / L ؟

0.0411

0.6850

0.00536

0.9970

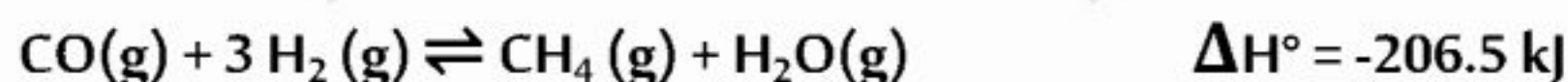


**Changes in temperature**

A change in temperature alters both the equilibrium position and the equilibrium constant.

Every chemical reaction is either endothermic or exothermic.

Endothermic means: Exothermic means:



Write this equation in a different way

.....

If heat is added to an equilibrium system, the equilibrium shifts in the direction in which heat is used up.

In the previous reaction, What is the effect of adding heat on the equilibrium?

.....

What is the effect of lowering the temperature on the equilibrium?

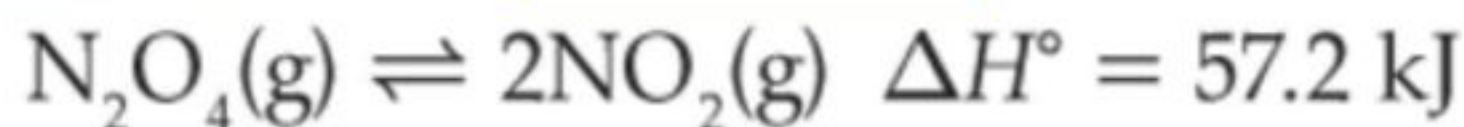
.....

Temperature and Keq

Any change in temperature results in change in Keq. The larger value of Keq means

For the methane- producing reaction, Keq increases in value when the temperature And

Keq decreases in value when the temperature

A different example

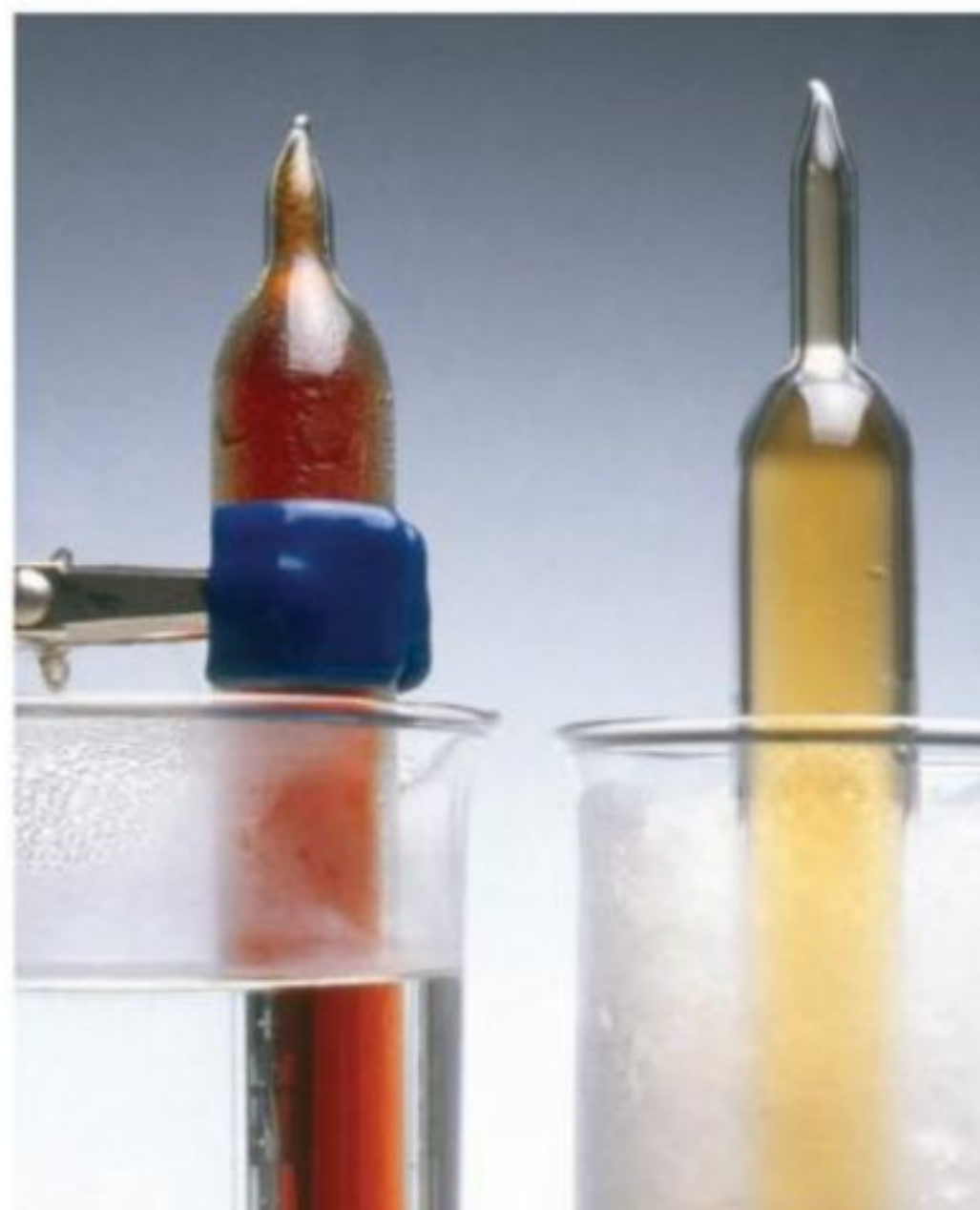
Because the reactant and product are different colors, the colors of the mixture give information about how temperature affects the equilibrium position.

N_2O_4 is a colorless gas; NO_2 is a reddish-brown gas.

Removing heat by cooling in ice shifts the equilibrium to the and creates more

Adding heat by hot water shifts the equilibrium to the and creates more

Figure 14 When placed in a hot-water bath (left), the equilibrium shifts in the endothermic direction, which produces more reddish-brown NO_2 . The mixture becomes lighter in color when placed in ice (right) because the equilibrium shifts in the exothermic direction, in which more NO_2 is converted to colorless N_2O_4 .

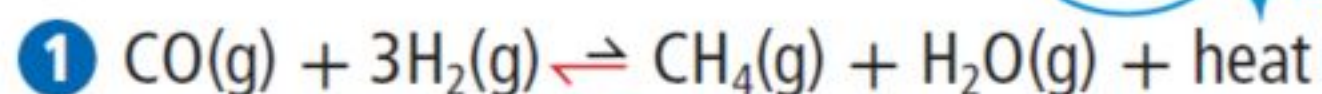




Exothermic Reaction

Equilibrium shifts to the left.

heat Raise the temperature.



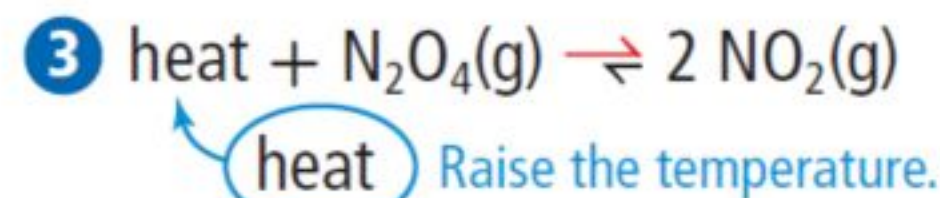
Equilibrium shifts to the right.

Lower the temperature.

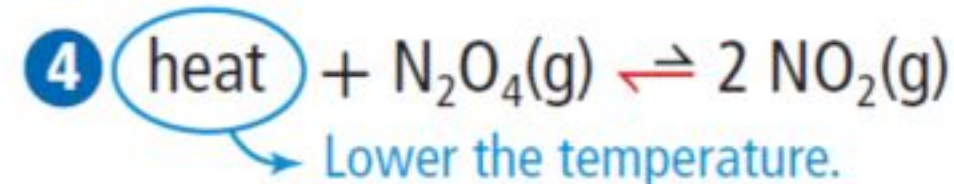


Endothermic Reaction

Equilibrium shifts to the right.

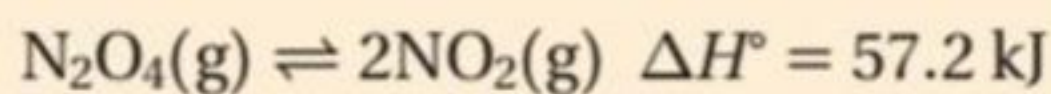


Equilibrium shifts to the left.

In the reactions 1,2,3,4 what is the effect of changing temperature on the value of K_{eq} ?

1		3	
2		4	

The reaction in the equation below is endothermic.

Which of the following is **correct**?

عديم اللون بني محمر



1



2

التفاعل في المعادلة أدناه ماص للحرارة.

أي مما يأتي **صحيح**؟

عند وضع وعاء التفاعل في حمام ساخن ينزاح الاتزان جهة اليسار
Placing reaction vessel in a boiling-water bath the equilibrium shifts to the left

عند وضع وعاء التفاعل في الثلج ينزاح الاتزان جهة اليمين
Placing reaction vessel in ice the equilibrium shifts to the right

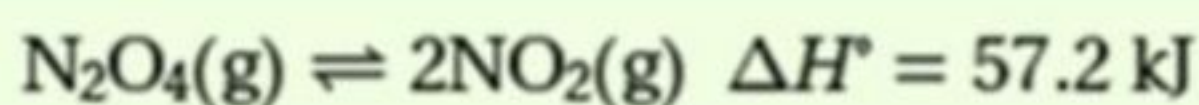
عند وضع وعاء التفاعل في حمام ساخن يظهر اللون 2
Placing reaction vessel in a boiling-water bath the color 2 appears

عند وضع وعاء التفاعل في الثلج يظهر اللون 2
Placing reaction vessel in ice the color 2 appears



The following reaction responds to changes in temperature in a remarkable way. What happens when the reaction vessel is placed in ice?

يستجيب التفاعل التالي للتغيرات في درجة الحرارة بطريقة ملحوظة، ماذا يحدث عند وضع وعاء التفاعل في الثلج؟



عديم اللون	بني محمر
colorless	reddish-brown



The equilibrium shifts to the right and the concentration of NO_2 increases

ينزاح الاتزان نحو اليمين ويزداد تركيز NO_2

The equilibrium shifts to the left and the concentration of N_2O_4 decreases.

ينزاح الاتزان نحو اليسار ويقل تركيز N_2O_4

The equilibrium shifts to the left and becomes colorless

ينزاح الاتزان نحو اليسار ويصبح عديم اللون

The equilibrium shifts to the right and becomes reddish-brown

ينزاح الاتزان نحو اليمين ويزداد اللون البني المحمر

THE GARDEN ACADEMY
Your Guide to Success

Tarek Mohamed

Tarek Mohamed

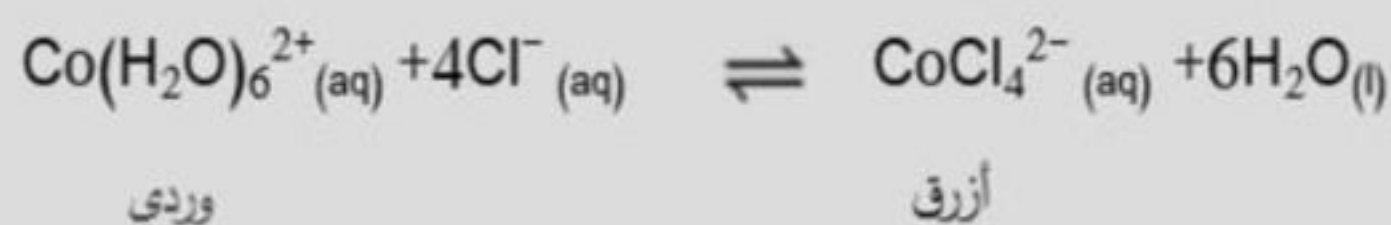
Tarek Mohamed

Tarek Mohamed

The figure below shows the following endothermic reaction at equilibrium at room temperature.

يُوضح الشكل أدناه التفاعل الماص للحرارة التالي عند الاتزان في درجة حرارة الغرفة. ماذا يحدث إذا تم وضع الدورق في حوض به ثلج؟

What happens if the flask were placed in an ice bath?



The equilibrium shifts to the left and the pink color increases

ينزاح الاتزان نحو اليسار ويزداد اللون الوردي

The equilibrium shifts to the right and the concentration of Cl^- ions increases

بنزاح الاتزان نحو اليمين ويزداد تركيز أيونات الكلوريد Cl^-

The equilibrium shifts to the left and the concentration of CoCl_4^{2-} ions increases

ينزاح الاتزان نحو اليسار ويزداد تركيز أيونات CoCl_4^{2-}

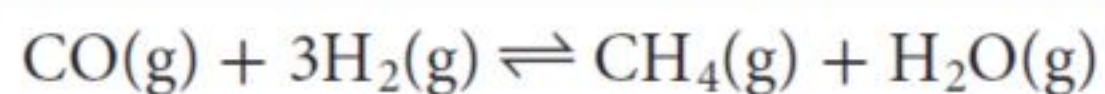
The equilibrium shifts to the right and the blue color increases

ينزاح الاتزان نحو اليمين ويزداد اللون الأزرق



Changes in volume and pressure

Consider this reaction



The reaction between CO and H₂ is at equilibrium.

Lowering the piston decreases the volume and increases the pressure.

As a result, more molecules of the products form. Their formation relieves the stress on the system.

Figure 13 For the reaction between CO and H₂ at constant temperature, changing the volume of the reaction vessel changes the concentrations of gaseous reactants and products. Increasing the pressure shifts the equilibrium to the right and increases the amount of product.

Explain how this figure supports the idea that, in many situations, a dynamic, condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

At low pressure, there are Product and reactant molecules.

At higher pressure, there are Product and reactant molecules.

The overall effect is a reduction of the number of molecules in the reaction chamber from to

Decreasing the volume or increasing the pressure has a relationship with the number of **gas particles** of reactants and products.

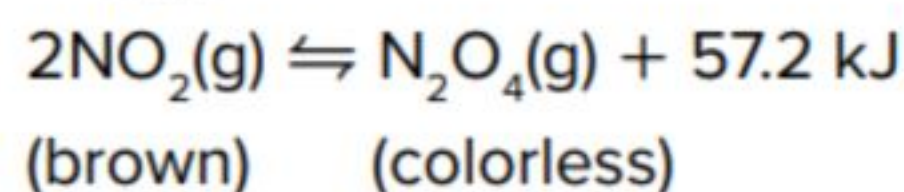
Compare the number of moles of gaseous reactants in the equation to the number of moles of gaseous products.

How does the equilibrium respond to the stress of increased pressure?

If the number of moles of gas is the same on both sides of the equation, changes in volume and pressure have no effect on the equilibrium.

Question:

The equilibrium between NO₂ and N₂O₄ is described by the equation



What is the effect of increasing the volume of the container?

On the particles:

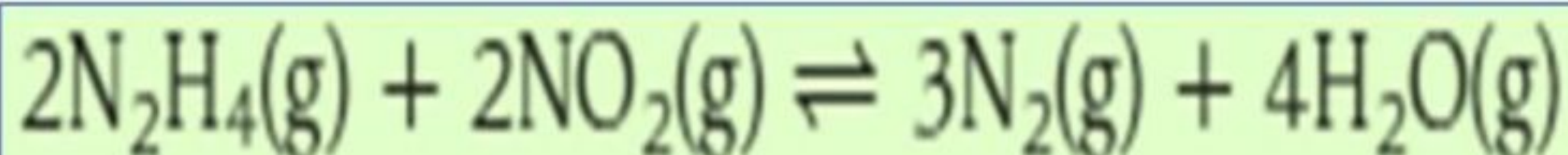
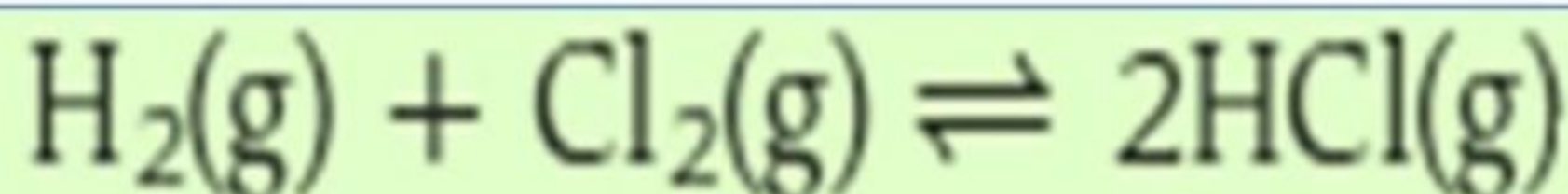
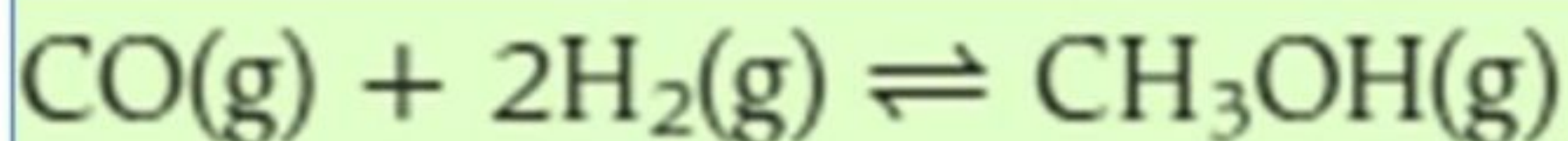
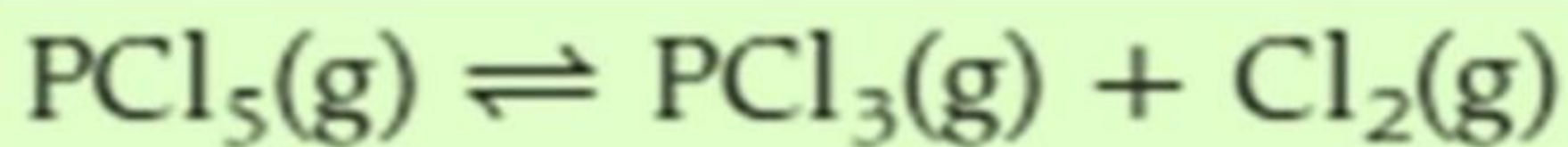
On the color:





In which of the equilibrium reactions below, does a reduction in the volume of the reaction vessel result in a displacement of the equilibrium **to the right and the amount of product increases?**
(at constant temperature)

في أي تفاعلات الاتزان أدناه، يؤدي تقليل حجم وعاء التفاعل إلى إزاحة الاتزان نحو اليمين وزيادة كمية الناتج؟
(عند درجة حرارة ثابتة)



What is the effect of decreasing the volume of the reaction vessel on the equilibrium systems below?

ما تأثير تقليل حجم وعاء التفاعل على أنظمة الاتزان أدناه؟

$\text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$	1
$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g})$	2

The equilibrium in both **1,2** shifts to the right

ينزاح الاتزان في كل من **1 و 2** جهة اليمين

The equilibrium **1** shifts to the left and the total number of gas moles increases

ينزاح الاتزان **1** جهة اليسار ويزداد عدد مولات الغاز

The equilibrium **1** shifts to the right and the total number of gas moles decreases

ينزاح الاتزان **1** جهة اليمين ويقل عدد مولات الغاز

The equilibrium **2** shifts to the left

ينزاح الاتزان **2** جهة اليسار



Regarding the equilibrium systems given in the table below.

Which of the following is **correct**?

فيما يتعلق بأنظمة الاتزان الواردة في الجدول أدناه.

أي مما يأتي **صحيح**؟

$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g})$	1
$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$	2
$\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$	3
$2\text{N}_2\text{H}_4(\text{g}) + 2\text{NO}_2(\text{g}) \rightleftharpoons 3\text{N}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$	4

Increasing the volume of the reaction vessel
shifts the equilibrium **4** to the left

زيادة حجم وعاء التفاعل يسبب إزاحة الاتزان **4** إلى اليسار

Decreasing the volume of the reaction vessel
shifts the equilibrium **1** to the right

تقليل حجم وعاء التفاعل يُسبب إزاحة الاتزان **1** إلى اليمين

Increasing the volume of the reaction vessel
shifts the equilibrium **3** to the right

زيادة حجم وعاء التفاعل يسبب إزاحة الاتزان **3** إلى اليمين

Decreasing the volume of the reaction vessel
shifts the equilibrium **2** to the left

تقليل حجم وعاء التفاعل يسبب إزاحة الاتزان **2** إلى اليسار





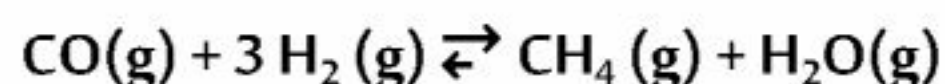
Changes in concentration

The number of collisions between reacting particles depends on the concentration of the particles, so the chemist can change the equilibrium by changing concentrations.

Adding reactants

Raising the concentration of any reactant increases the number of effective collisions between reactants and upsets the equilibrium.

The rate of the forward reaction increases



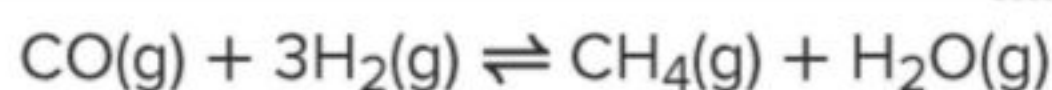
What is the effect of adding more CO in the previous reaction?

Removing products

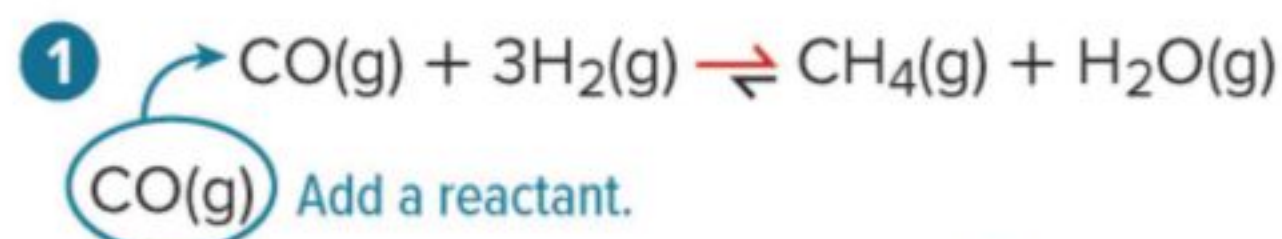
What does Le Châtelier's principle predict the equilibrium will do in response to a decrease in the concentration of water?

Adding products

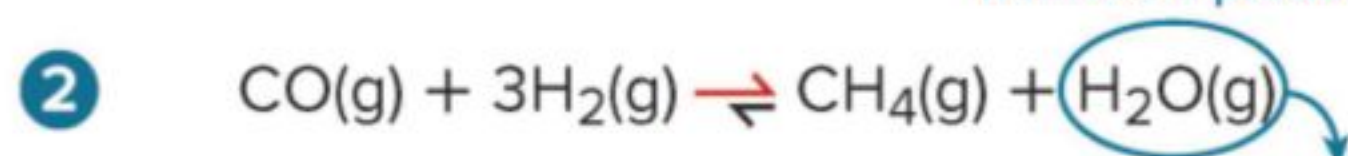
If additional product is added to a reaction at equilibrium, the reaction will shift to the left. If one of the reactants is removed, a similar shift to the left will occur.



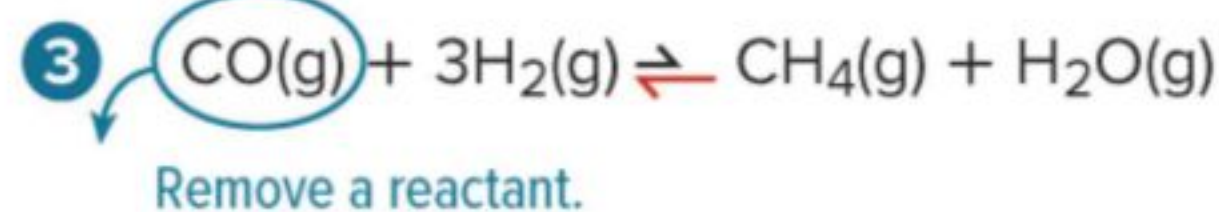
Equilibrium shifts to the right.



Remove a product.



Equilibrium shifts to the left.



Add a product.

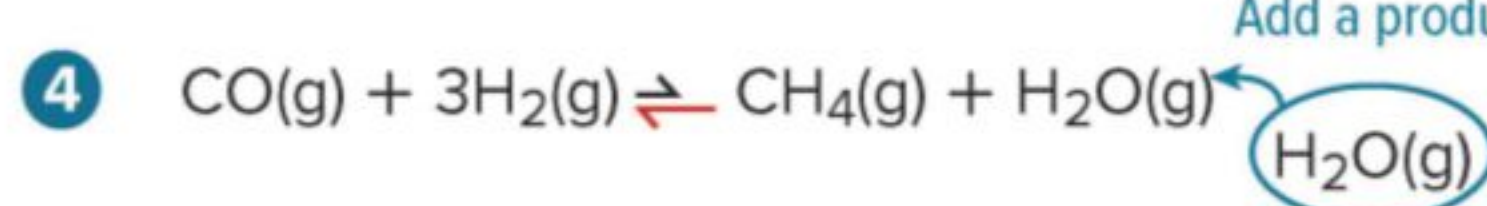
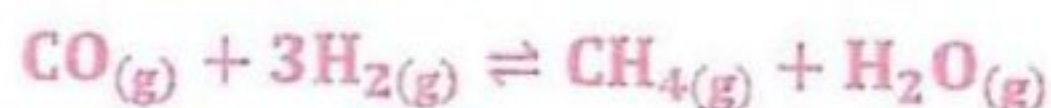


Figure 12 The addition or removal of a reactant or product shifts the equilibrium in the direction that relieves the stress. Note the unequal arrows, which indicate the direction of the shift.

Describe how the reaction would shift if you added H₂. If you removed CH₄.

14. If CH₄ is removed from this reaction :



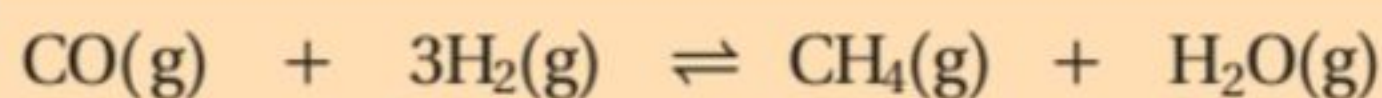
Which of the following will happen?

- the equilibrium shifts to the right
- the equilibrium shifts to the left
- [H₂] and [CO] increases
- no change in equilibrium position



Which of the following factors shifts the equilibrium in the reaction below to the right?

أي العوامل التالية تُسبب انزياح الاتزان في التفاعل أدناه جهة اليمين؟



Adding a desiccant to the reaction vessel

· إضافة عامل مجفف في وعاء التفاعل

Increasing the concentration of methane

زيادة تركيز الميثان

Decreasing the concentration of CO

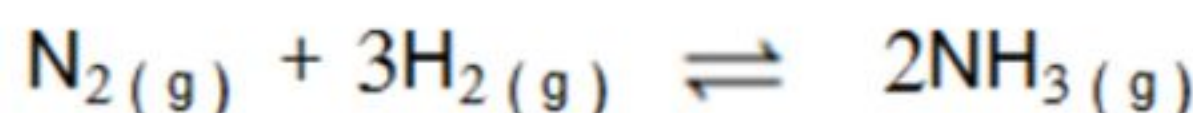
· تقليل تركيز CO

Decreasing the concentration of H₂

تقليل تركيز H₂

In the equilibrium below, How is the increasing of the concentration of N₂ gas affects the equilibrium?

في الاتزان أدناه، كيف تؤثر زيادة تركيز غاز النيتروجين N₂ على نظام الاتزان؟



A – The equilibrium shifts to the left

A – ينزاح موضع الاتزان نحو اليسار

B – Increases the concentration of H₂

B – يزيد من تركيز H₂

C – The equilibrium shifts to the right

C – ينزاح موضع الاتزان نحو اليمين

D – Decreases the concentration of NH₃

D – يُقلل من تركيز NH₃

In the following equilibrium reaction:

في تفاعل الاتزان التالي:



What is the effect of removing O₂ from the reaction vessel?

ما أثر إزالة O₂ من وعاء التفاعل؟

The concentration of both SO₂ and SO₃ does not change

لا يتغير تركيز كلا من SO₂ و SO₃ ☐

The concentration of SO₂ decreases

ينقص تركيز SO₂ ☐

The concentration of SO₃ increases

يزداد تركيز SO₃ ☐

The concentration of SO₂ increases

يزداد تركيز SO₂ ☐



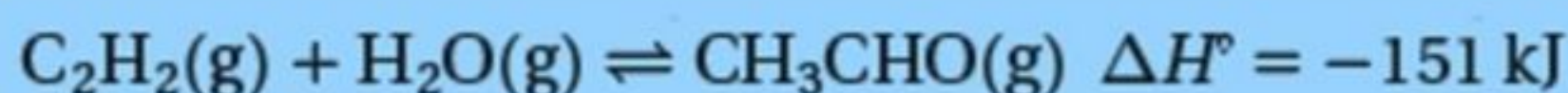
Catalysts and equilibrium

A catalyst speeds up a reaction, but it does so equally in both directions. Therefore, a catalyzed reaction reaches equilibrium more quickly but with no change in the amount of product formed.

What is the effect of a catalyst on a chemical reaction in equilibrium?	ما أثر الحفاز على تفاعل كيميائي في حالة اتزان؟
Speeds up the reverse reaction more than the forward reaction	يزيد من سرعة التفاعل العكسي أكثر من سرعة التفاعل الأمامي
The reaction reaches equilibrium more quickly	يصل التفاعل بشكل أسرع إلى حالة الاتزان
Speeds up the forward reaction more than the reverse reaction	يزيد من سرعة التفاعل الأمامي أكثر من سرعة التفاعل العكسي
Changes in the amount of product formed	يُغير في كمية المادة الناتجة المتكونة

Which of the following increases CH_3CHO production in the following equilibrium reaction?

أي مما يلي يؤدي إلى زيادة إنتاج CH_3CHO في تفاعل الاتزان التالية؟



Decreasing temperature	خفض درجة الحرارة	1
Adding a lot of water	إضافة المزيد من الماء	2
Adding a catalyst	إضافة عامل حفاز	3
Adding a desiccant	إضافة عامل مجفف	4
Increasing temperature	رفع درجة الحرارة	5

1 and 4

1 و 4

1 and 2

1 و 2

3 and 4

3 و 4

4 and 5

4 و 5

بطاقة الكيمياء

صف 12 متقدم

شرح أ. طارق محمد



جاهز للنجاح وإطلاق إبداعاتك



فيديوهات ▶ ملازم شرح ▶ أوراق عمل ▶ اختبارات

مراجعة تفصيلية شاملة للهيكل

للاشتراك في البطاقة واتساب الدعم
الفني للأكاديمية 0569174493